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FINAL:

ENVIRONMENTAL IMPACT STATEMENT
FOR THE AIR POLLUTION VARIANCE

REQUESTED BY:

THE ANACONDA COMPANY
FOR ITS SMELTER AT ANACONDA, MONTANA

April 26, 1974

Department of Health and Environmental Sciences
John S. Anderson, M.D., Director
Environmental Sciences Division
Benjamin F. Wake, Administrator
Air Quality Bureau
Don Holtz, Chief

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FOREWORD

This statement has been prepared by the Environmental Sciences Division of the State Department of Health and Environmental Sciences, pursuant to the Montana Environmental Policy Act, (MEPA) Section 69-6504(b)(3).

The MEPA requires preparation of an environmental impact statement whenever a state agency is considering some action that could result in a significant impact on the environment. The action contemplated in this case is a decision regarding an application for an air pollution variance by The Anaconda Company for their copper smelter in Anaconda, Montana.

This department, with the help of other agencies and members of the public, must decide whether granting the variance would result in the continuation of emissions into the air to an extent sufficient to constitute danger to the public health or safety, and whether denial of the variance would produce hardship without equal or greater benefits to the public.

Comments or questions regarding the impact statement or the proposed pollution variance should be directed to Daniel Vichorek, Technical Writer, Environmental Sciences Division, Cogswell Building, Helena, Montana, 59601. Other than a public hearing, there will be no official action on the variance request for at least 30 days following issuance of this statement.

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SUMMARY

The Anaconda Company has requested a variance from the state's sulfur oxide emission standard. The variance is sought for one year, the maximum period for which a variance may be granted, although it may be renewed if such action seems reasonable.

The company says it cannot now operate the smelter to comply with the standard and it seeks time to continue the design and construction of additional unspecified air pollution control devices.

It has been demonstrated to the satisfaction of this department that equipment is available at a reasonable cost to bring the smelter into compliance with the emission standard. Such equipment is in operation on other smelters with emission parameters similar to those of the Anaconda operation.

Lacking adequate emission control, the smelter causes frequent gross violations of the sulfur oxide ambient standard in the Deer Lodge Valley, resulting in damage to vegetation and threats to the health and property of the residents.

Considering all the facts above, this department concludes that the benefits that might result from granting the variance would be more than negated by the resulting impacts on the environment and the public.

The department therefore recommends that the State Board of Health and Environmental Sciences deny the variance.

Having received and taken into consideration public comment on the draft environmental impact statement, the department is now prepared further to recommend adoption of a compliance schedule to bring the smelter emissions into full compliance with state standards.

I. INTRODUCTION

A. Description of the Proposed Action

1. The Anaconda Company has requested a variance from Section 16-2.14(1)-S1470 of the Montana Administrative Code, pertaining to sulfur emissions from the copper smelter at Anaconda (Appendix A).

The pertinent portion of this code says "No person or persons shall cause, suffer, allow or permit to be discharged into the outdoor atmosphere from any copper, zinc or lead smelting operation or any slag treatment plant reduced sulfur in excess of the amount shown in the following table."

Total Feed of Sulfur lb/hr	Allowable Sulfur Emission, lb/hr Cu	Zn	Pb
1,000	100	100	100
5,000	500	394	348
10,000	1,000	704	593
20,000	2,000	1,270	1,000
40,000	4,000	2,310	1,000
60,000	6,000	3,210	1,000
80,000	8,000	4,120	1,000
100,000	10,000	5,000	1,000
over 100,000	10,000	5,000	1,000

2. Definition and Purpose of Variances

Under the Clean Air Act of Montana, Section 69-3916 (Appendix B) any person who owns or controls any plant, building, structure, process or equipment may apply to the State Board of Health for an exemption or partial exemption from rules or regulations governing the quality, nature, duration or extent of air polluting emissions.

The Board may grant such exemptions only if it finds that the emissions occurring or proposed to occur do not constitute a danger to public health and do not constitute a danger to public safety and only if compliance with the rules or regulations from which variance is sought would produce greater public hardship than public benefits.

The act states further that no exemption or partial exemption shall be granted . . . except after public hearing on due notice and until the Board has considered the relative interests of the applicant, other owners or property likely to be affected by the emissions, and the general public.

Variances may not be granted for periods greater than one year at a time, but they may be renewed under certain conditions stipulated by the Board.

B. Company's Proposals Per Variance Request

The Anaconda Company presently is producing about 34 million pounds per month of anode copper. The only equipment in operation as of April, 1974, for control of sulfur oxide emissions is the 660 tons per day (T/day) sulfuric acid plant which the Company calculates will retain about 32% of the total sulfur input to the pyrometallurgical smelter when rated capacity is achieved. On March 5, 1974, Anaconda Company officials announced to the Department of Health and Environmental Sciences that the capacity of the sulfuric acid plant would be increased from 660 to 990 T/day of acid provided "than an acceptable means of disposal can be found for the additional acid." Before the increased acid capacity could be put into production the fluo-solids roaster and electric furnace proposed in the variance request would have to be operational. Approximately 50% of the input sulfur to the pyrometallurgical smelter then would be retained.

In its request for a variance from Regulation 16-2.14(1)-S1470(2) (Appendix C), submitted to the Montana State Department of Health and Environmental Sciences, The Anaconda Company has asked that:

1. A variance be granted for one year

2. Operation of the applicant's smelter at Anaconda, Montana, be allowed to continue because it does not include equipment to restrict sulfur emissions to 10% of total feed as required by the regulation

3. Additional time be granted to continue design and construction of additional air quality control devices

The future control plan as envisioned by The Anaconda Company is outlined below.

1. Complete Phase I of the smelter expansion program as established in 1971. This phase includes the 660 T/day sulfuric acid plant, the installation of a new flue and water-cooled hood system to exhaust converter off-gases.

2. Construction and operation of the Arbiter hydrometallurgical plant to produce an additional 6 million pounds of copper per month, increasing total copper production from 35 to 41 million pounds per month. This plant will not discharge sulfur oxide gases.

3. Installation of a fluo-solids roaster and electric furnace to replace the drying and reverberatory furnaces.

Completion of Phase I of the smelter expansion program will partially achieve compliance with state regulations for sulfur oxide emissions. The company usually refers to the sulfuric acid plant as an environmental control (Reference 1), but about 250 T/day of the acid produced is used for concentrate and precipitate production at the Butte mines (Ref. 2). A contract to sell 50,000 tons of sulfuric acid by the end of 1974 has been obtained (2). This amount of acid is equivalent to a daily production of 91.3 T/day every day for 18 months. The two uses of the acid amount to almost 52% of present capacity (2).

The Anaconda Company has not stated in the variance request (Appendix C) that means for sulfur oxide removal from the flue gases from the proposed fluo-solids roaster or electric furnace would be installed. As of April, 1974, no construction applications have been requested nor any construction schedules released for these two units. Nor does the Company state in the variance request that additional converter off-gases will be treated. They have however, recently revealed that the acid plant capacity might be increased from 660 to 990 T/day.

II. DESCRIPTION OF PLANT AND PROCESSES

A. Basic Manufacturing Processes

1. Pyrometallurgical Smelter

The Anaconda Company smelter at Anaconda, Montana, treats ores, copper concentrates and precipitates to produce anode copper. About 2360 T./day of raw materials, based on company production records from January through August, 1973 (Ref. 3), are used in the smelting process with about 1.17 million pounds per day (lb/day) of anode copper produced. A schematic flow diagram of the smelter is shown in Figure 1. Concentrates now come by rail from the Weed Concentrator at Butte, from Yerington, Nevada and the Brittania and Craigmont mines in British Columbia, Canada. Since November, 1973, copper ore has been shipped by rail from the Continental East Pit at Butte. A future source may be the Twin Buttes property in Arizona but this is not likely to happen for several years. Precipitates are shipped by rail from the Precipitate Plant located near the Berkeley Pit in Butte, from Yerington, Nevada, and from British Columbia (2).

The approximate proportions of plant feed from each source are shown in Table 1. The overall copper and sulfur contents of the smelter feed (concentrates and precipitates) are about 35.1% and 31.4% respectively. An approximate smelter sulfur balance is shown in Figure 2.

Ore from the Continental East Pit is crushed at the East Anaconda crusher and concentrated in the facilities at the smelter complex. All concentrates and limestone are dried in the eighteen multiple tray roasters in roaster building no. 2. Even though these facilities were originally used as roasters, only drying is now done. Roaster building no. 1 is only used for storage.

The smelting process begins in the reverberatory furnaces. Four natural gas fired furnaces, each about 120 feet long, 60 feet wide and 50 feet high, consuming up to 7.2 billion cubic feet of natural gas each year (2) are periodically charged with limestone-concentrate mixture, silica rock, and converter slag.

Figure 1. Flow Diagram - Anaconda Smelter

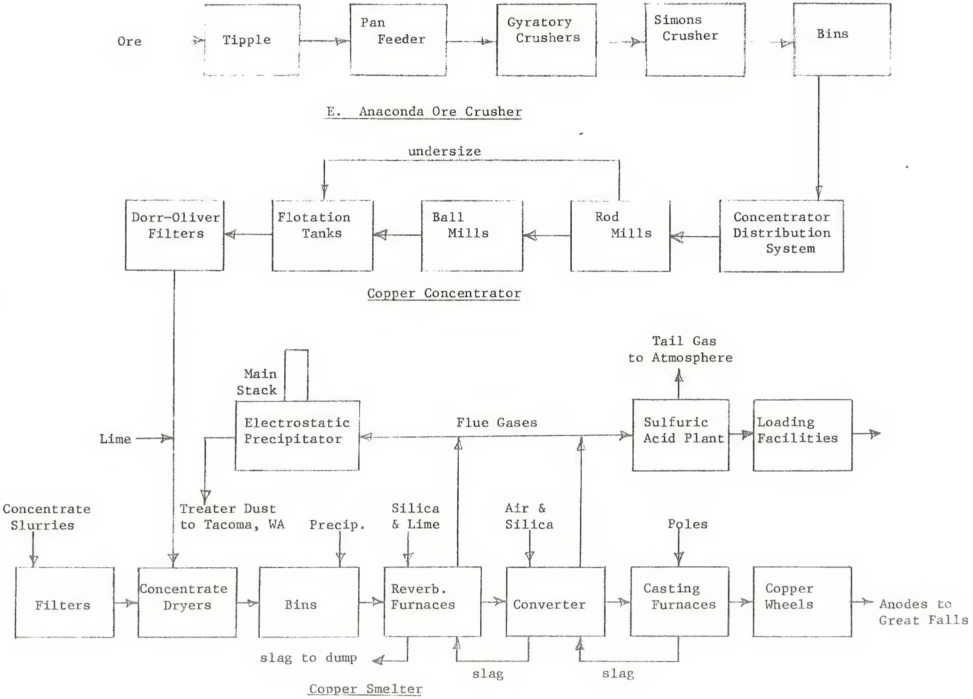


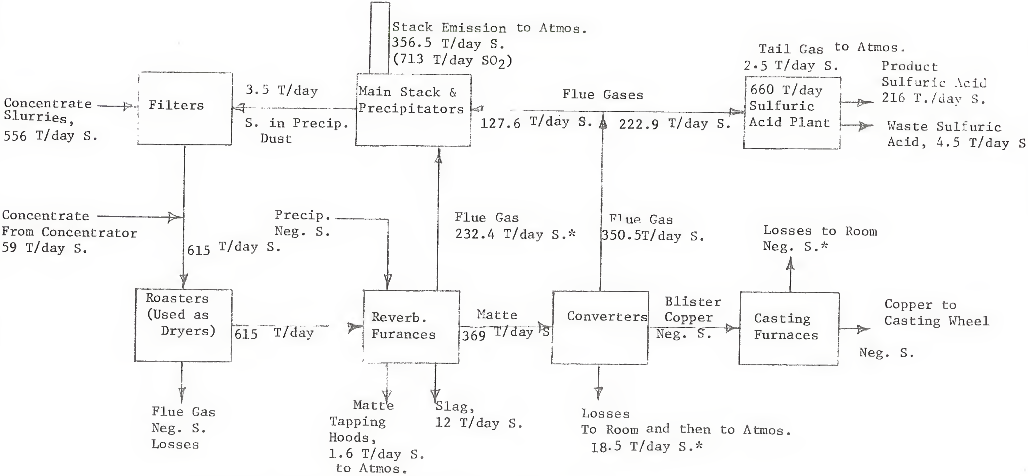
TABLE 1

Smelter Copper Feed, 1973 (Ref. 2)

Source	% of Total Ores Concentrates & Precipitates	% Sulfur in Column 1
Weed Concentrator Butte	70.2	36.3
Concentrates, Yerington, Nevada	13.1	31.5
Precipitates, Yerington, Nevada	3.5	1.3
Concentrates, Brittania Mine B.C., Canada	5.0	35.3
Precipitates, Brittania Mine, B.C., Canada	0.2	2.0
Precipitate Plant, Butte	8.0	nil
Total	100.0	-
Average	-	31.4

FIGURE 2

Approximate Smelter Sulfur Balance with Fully Operational Sulfuric Acid Plant and Smelter at Rated Capacity



*Estimated quantities, never measured by The Anaconda Company
Note: The sulfur in natural gas is negligible.

Emissions to Atmosphere.
Allowable - 61.5 T/day
Main Stack - 356.5 T/day
Converter Room Losses - 18.5 T/day
Matte Tapping Hoods - 1.6 T/day
Acid Plant Tail Gas - 2.5 T/day
Total Losses - 379 T/day

Limestone and silica are fluxing agents. The furnaces are kept nearly full at all times and the contents are maintained at about 2000°F. The emissions from the reverberatory furnaces consist of particulate matter in many chemical forms, some of which are metallic fumes, metallic sulfides, metallic oxides, silica, and sulfuric acid. Gaseous emissions include sulfur oxides, nitrogen oxides, and carbon monoxide. Currently the flue gases containing these emissions are cooled in spray chambers from about 2400°F. to 700°F. and then flow through the main flue to the electrostatic precipitators at the base of the main stack. The slag removed from the reverberatory furnaces is moved by a water filled flume to a pond and then by dragline to the dump. The slag contains about 2% sulfur which amounts to about 2% of the smelter input sulfur. The product, copper matte, is transferred by ladles to the converters (furnaces). The matte consists of about 46% copper, 24% iron, 25% sulfur and 5% other materials. (3, 4) About 60% of the sulfur in the feed remains in the matte, about 38% is contained in the furnace off-gases. This reverberatory furnace off-gas contains about 1-2% sulfur dioxide (5).

The copper matte is converted to blister copper in one of the eight converters. Air, silica, copper matte, and casting furnace slag comprise the charge to these furnaces. The primary purpose of these furnaces is to reduce the metallic sulfides of the matte into metallic copper, leaving slag and releasing sulfur oxide gases. The sulfur oxides that are driven off, about 98% of the sulfur in the converter charge, are collected in a water-cooled hood and flue system which is designed to have a collection efficiency of 95% (5). No measurements of actual efficiency have been made. About 67% of this flue gas goes to the 660 T./day sulfuric acid plant for conversion to sulfuric acid. The other 33% passes through the main flue and main stack to the atmosphere. Both collection efficiencies and treatment efficiencies have been mentioned above. The difference should be kept separately in mind.

The sulfuric acid plant includes an 80,000 standard cubic feet per minute (SCFM) Ducon wet scrubber and two electrostatic precipitators to clean the inlet gas.

About 2% of the sulfur oxides entering the scrubber are dissolved by the water. The primary purpose of the precipitators is to remove water mist. Of the remaining 98% of the sulfur oxides passing the cleaning units, about 99% is converted to sulfuric acid and the remainder, about 500 parts per million (ppm) or 2.5 T./day sulfur dioxide, is discharged to the atmosphere through a 120-foot tall stack. In summary, the acid plant removes about 67% of the sulfur in the converter off-gases and only about 36 of the total smelter input sulfur.at rated capacity.

The slag formed in the converters is relatively high in copper and is returned to the reverberatory furnaces for additional processing. The converter product, blister copper, is transferred by ladle to one of four casting furnaces where it is treated by "poling" or natural gas injection, which are oxide reducing processes, and poured into one of the casting wheels to form copper anodes (5). Low concentration emissions from two of these furnaces are collected and exhausted outside the building as an occupational health control measure. The copper anodes are shipped to Great Falls, Montana, for purification.

A silica rock quarry about 3 miles Southwest of the smelter complex supplies 120-320 T./day of material for the smelting process (6). Transportation is by rail.

A limestone quarry several miles west of the town of Anaconda produces about 1250 T./day of rock (calcium carbonate) most of which is processed in two lime kilns for use in the concentration processes at Butte and Anaconda and for waste water neutralization (7). No processing of the limestone is required when it is used as flux in the smelting process.

Lime kiln no. 1 receives about 300 T./day of limestone rock and lime kiln no. 2 receives about 800 tons (7). This limestone rock is "burned" in natural gas-fired rotary kilns at about 2000°F. to form "burnt lime" (calcium oxide). This material is then slaked with water to form milk of lime (calcium hydroxide) and then transported by rail to the Weed Concentrator or other usage points. About 195×10^6 cubic feet (ft.^{3}) of natural gas are consumed per month by the two lime kilns (2).

The ore/crusher at East Anaconda now processes Butte ore two shifts per day. About 14,000 T./day of ore are crushed and sent to the copper concentrator where the amount of material is reduced to 175 T./day containing 31.5% copper and 33.6% sulfur (8). The concentrator operates on a continuous basis.

As of April, 1974, twelve natural gas-fired boilers were operating at the smelter producing steam primarily for heating buildings. The total rating of these boilers is 2,450 horsepower. This is equivalent to a steam generating capacity of about 100,000 lbs/hr. Natural gas consumption by these boilers is 108,000 cubic feet per hour (8). Generation of steam from the hot reverberatory furnace flue gases was discontinued in 1972 (9). When in use, the last waste heat boiler generated about 20,000 lbs/hr of steam.

Many processing areas in the smelter complex are now inactive. This includes three sulfuric acid plants with acid capacities of 200, 150 and 100 T./day, the arsenic plant, the zinc crusher, zinc concentrator, zinc leaching plant, zinc purification plant and the manganese flotation plant. The phosphate plant was dismantled in 1971 and the sponge iron plant will be torn down in the near future. The three acid plants once processed gases from the zinc roasters that are no longer operating (10).

2. Hydrometallurgical Plant (Arbiter Plant)

This new plant was evaluated in a separate environmental impact statement prepared by the Air Quality Bureau, Montana State Department of Health and Environmental Sciences and issued in December, 1973. A complete description of the process is contained in that document and is only briefly outlined here. Startup of this plant is expected to be late in 1974.

The hydrometallurgical plant was designed to produce 6 million pounds of cathode copper per month. The copper concentrates, pumped to the plant as a slurry, will be diluted with process liquor and agitated in pressure vessels in the presence of oxygen and ammonia. The product, a slurry containing copper amine sulfate solution, will then pass through thickeners where the solid material will be removed. The solid material will then go to flotation cells where metal values will be separated from the waste. The flotation tailings and waste gypsum from another part of the process will be combined and pumped to a tailings reservior as a slurry.

The copper amine sulfate solution will be stripped of its copper content in a solvent extraction process. This copper rich solvent will be mixed with spent electrolyte where it will give up the copper to produce enriched electrolyte. The strong electrolyte will be pumped to the electrowinning building for electrolytic plating of the copper onto lead cathodes. The spent solvent will be recycled to pick up more copper from the copper amine sulfate solution.

Small portions of the spent electrolyte and leaching solutions will be removed and neutralized with milk of lime to maintain proper component balances. The waste material, calcium sulfate, will be mixed with the flotation tailings for disposal.

Important auxiliary equipment required for this process include the ammonia vent system, oxygen plant, boiler plant, and electrode casting facility.

The ammonia vent system will remove ammonia discharged from equipment containing strong solutions and pass these gases through a fractionating tower or wet scrubber before discharging the cleaned gases to the atmosphere.

The oxygen plant was designed and will be built and operated by Linde Division of Union Carbide Corporation. It will be capable of producing 115 T./day of gaseous oxygen and 5 T./day of liquid oxygen.

The boiler plant will have 3 boilers, each capable of producing 90,000 lbs/hr of steam at 125 pounds per square inch gage (psig). Each of two smaller boilers will produce 6,000 lbs/hr of steam at 850 psig. One boiler of each size will be a standby unit. All boilers will be fired with natural gas.

Since this is a new process, plant emissions can only be predicted. Sulfuric acid mist from the roof vents of the electrowinning building, ammonia from the wet scrubber, and sulfur oxides and nitrogen oxides from the boilers are expected. All such emissions will be minimal, however, because of the solubility of effluents and the design of the facilities.

B. Sources of Pollution

1. Sulfur Oxides

The Anaconda smelter is the largest emission source of sulfur oxides in the state. It is over twice as large as the next largest source and about 40 times as large as any of the petroleum refineries. The reverberatory furnaces and the converters generate nearly all of the sulfur oxides now emitted from the Anaconda smelter.

At rated smelter capacity of 35 million lb copper/mo. about 38% or 468 T/day of the sulfur oxides generated at the smelter come from the reverberatory furnaces (5). Here the sulfur dioxide concentrations are low due to dilution with fuel combustion gases and are not normally suitable for acid plant feed (11). All of these gases discharge directly to the main stack with no sulfur dioxide removal.

At rated smelter capacity the converters generate approximately 737 tons per day of SO_2 some 67% of which is removed in a 660 T/day sulfuric acid plant. The other 33% passes through the flue system to the main stack. The hoods on the converters collect about 95% of the gases generated by the converters; the remaining 5% escaping into the building and exhaust via roof ventilation fans to the outside atmosphere (5, 12).

Smaller quantities of sulfur oxides emit from the tapping of slag and matte.

The roasters presently function only to dry the incoming smelter feed and emit almost no sulfur oxides.

2. Particulate

The many particulate emission sources at the Anaconda smelter include reverberatory furnaces, converters, roasters, casting furnaces, lime kilns, foundry, crusher and the two quarries.

The main stack releases large quantities of particulate generated at the reverberatory furnaces and converters into the atmosphere. These particulates are mainly oxides of heavy metals, including zinc, arsenic, lead, copper, etc. (9, 13). Sulfates may also exist as primary or secondary pollutants. The long flue leading to the stack acts as a settling chamber with some further particulate removal in an old electrostatic precipitator at the base of the stack. Estimated overall efficiency of these systems is 73% (9), leaving an emission of 31 T/day of particulate (3).

A baghouse with an estimated efficiency above 99% is now under construction to remove particulate from the reverberatory-converter off-gases.

The portion of the converter gases routed to the acid plant is thoroughly cleaned of particulate by the scrubber prior to entering the acid plant.

The drying operation now performed in one of the roasters releases only small amounts of particulate which are vented to the main stack.

Gases from the two lime kilns at the Anaconda smelters are cleaned of particulate by scrubbers, with an estimated total aerial emission of 20 lbs/hr (7).

Casting furnaces emit combustion gases and only small amounts of particulate.

The foundry cupola furnaces operate for only 5 hours in every 10 days. During that operation, large amounts of particulate are emitted. Emission rates have been measured at 255 lbs/hr (7).

C. History of Plant and Existing Control

The Clean Air Act of Montana (1967) says: "It is hereby declared to be the public policy of this state and the purpose of this act to achieve and maintain such levels of air quality as will protect human health and safety, and to the greatest degree practicable, prevent injury to plant and animal life and property, foster the comfort and convenience of the people, promote the economic and social development of this state and facilitate the enjoyment of the natural attractions of this state."

The State Board of Health was given the responsibility for administration of the act through the assistance of a Director of Air Pollution Control and subordinate employees. An Air Pollution Control Advisory Council consisting of the Executive Officer of the State Board of Health and ten members appointed by the Governor was created to advise the Board of Health. The administrative duties associated with the Act are now handled by The Air Quality Bureau of the Department of Health and Environmental Sciences.

The Board of Health with its power to "Adopt, amend, and repeal rules implementing and consistent with the provisions of this Act" promulgated regulations 90-008, Sulfur Oxide Emissions and 90-015, Ambient Air Quality Standards, in April, 1970 and November 1969, respectively. Another regulation, 90-007, Visible Air Contaminants, was adopted in stages from November, 1968 through June, 1970. All three regulations are included in Appendix A.

In 1971 The Anaconda Company requested a change in the state sulfur oxide regulation. On December 15, 1971, a lengthy public hearing before the State Board of Health was held, and the request was denied.

In January, 1972, Governor Anderson submitted the state's "Implementation Plan for Control of Air Pollution in Montana" to the Environmental Protection Agency (EPA) after deleting the section on sulfur oxide control. This action required EPA to promulgate its sulfur oxide emission standards for the Anaconda smelter. The proposed EPA rules were published on July 27, 1972. A public hearing on these proposed rules was held in Helena in August, 1972. In September, 1972, the Anaconda Company filed suit against EPA for what it considered improper procedure prior to promulgating these rules. In December, 1972, the U.S. District Court in Denver rendered a decision favorable to the Company. In July, 1973, the U.S. Court of Appeals for the Tenth Circuit reversed the decision of the lower court.

In June, 1973, the U.S. Supreme Court upheld lower court rulings on a suit by the Sierra Club against EPA, that EPA must disapprove all state implementation plans which did not contain provisions to prevent significant degradation of existing air quality in areas that had cleaner air than allowed by the national standards. In September, 1973, EPA held the first public hearing on how to achieve "no significant degradation" of air quality.

The Anaconda Company was granted a one-year variance for the smelter particulate emissions in July, 1973. About the same time the Company began construction of a new baghouse for control of these emissions.

The Anaconda Company's 1972 Annual Report states "The State of Montana has promulgated an emission standard [sulfur oxide] of the same magnitude as the one proposed by the federal agency. This standard is scheduled to go into effect on July 1, 1973 [sic] and Anaconda will seek relief from its enforcement." The regulation was effective June 30, 1973. On June 30, 1973, the Company's present variance petition was filed.

Copper production at the Anaconda smelter since 1966 has increased from 25.9 million pounds per month (lbs/mo) to the present capacity of about 35 million lbs/mo (14). Since 1967 changes in the copper production facilities (10) have been made by:

1. Eliminating zinc roasting in roaster building no. 2 in 1972 and changing from copper roasting to drying in 1971.
2. Increasing the number of converters from 6 in 1969 to 8 at the present time.
3. Increasing from 2 to 4 casting furnaces in 1972 and from 1 to 2 casting wheels at the same time.
4. The E. Anaconda crusher, previously used on a one or two day per week schedule, started processing Continental East ore at a daily double shift rate of 14,000 tons in November, 1973.
5. The original copper concentrator was reactivated in November, 1973, to process copper ore from the E. Anaconda crusher.

The new 660 T./day sulfuric acid plant and associated water-cooled converter hoods, ducts, and gas scrubber were installed from 1971 - 1973 to produce sulfuric acid from the converter off-gases. As of December, 1973, the acid plant was not being operated at full capacity (15). Use of this system at full capacity will remove particulate matter and sulfur oxides from about 67% of the existing converter off-gases. The reduction in emissions when this plant reaches full production will be about 446 tons per day of sulfur dioxide.

The electrostatic precipitator at the base of the main stack has been the primary particulate control device at this smelter since 1918. It is still in use but probably will be discontinued about 1975 when the new baghouse and the proposed electric smelting furnace are completed. The baghouse is now under construction and should treat a portion of the reverberatory furnace and converter off-gases by 1975. No construction schedule for the electric furnace has been announced.

Lime kiln no. 1 was built in 1955 to produce burnt lime and milk of lime (10). The original pollution control equipment consisted of a settling chamber in the flue system. A Notice of Violation from the State Air Quality Bureau for excessive emissions from this facility was served upon the Company in February, 1973. The problem which caused that notice was corrected by installing a Ducon wet scrubber in series with the settling chamber.

Lime kiln no. 2 was built in 1940-41 for use as a manganese nodulizing plant. This service was discontinued in 1964. It is now used as a lime kiln (10). The Company also received a Notice of Violation in February, 1973, for excessive emissions from this plant. That problem was also corrected when the Company installed water sprays in a section of the exhaust flue.

Roaster building no. 1 has been used as a concentrate storage facility since about 1958. It may be phased out of operation by about 1976 (10).

Roaster no. 2 was constructed about 1915. Roasting of concentrates was stopped in 1972 but the facility is now used to dry copper concentrates (10). The two electrostatic precipitators and gas scrubber used to clean the flue gases from the facility when it was used as a roaster are now idle. Combustion gases from the concentrate drying are vented to the main flue and are emitted to the atmosphere from the main stack.

The foundry was built about 1900 to fabricate parts for both the Butte and Anaconda operations. It is now used to provide the smelter with castings which cannot be purchased elsewhere (10). The emissions from the furnaces during charging violate state standards. The Company received a Notice of Violation for these emissions in February, 1973, with a requirement for correction by August 1, 1973. As of April, 1974, the Company has not reported any corrective action taken.

The silica and limestone quarries were both opened about 1900 and have been in continuous service ever since (10).

Zinc production ceased during the 1969-74 period (9). The following events took place:

1. The zinc leaching and purification plants were closed in 1969.
2. The three sulfuric acid plants treating zinc roaster off-gases were shut down in June, 1972.
3. Zinc roasting in roaster building no. 2 was discontinued in 1972.
4. The zinc plant at Great Falls closed in 1972.
5. The zinc crusher building was torn down in 1973. The zinc concentrator is idle but still usable for either zinc or copper concentration.

Manganese nodules were produced at this plant from the beginning of World War II until 1959 (10). This was started by request of the federal government but continued some time after that conflict had ended. This plant has been idle since 1959.

The phosphate plant construction started in 1948, and operations ceased in 1961. During this time, sulfuric acid made from zinc roaster off-gases was used to produce ammonium phosphate and treble super phosphate fertilizers and vanadium oxides. Much of this plant has been dismantled since 1961. The three sulfuric acid plants, with a total acid capacity of 450 T./day, are now idle but still usable (2,10).

Sponge iron, used as a precipitating agent in the copper leaching process, was manufactured at Anaconda from 1951 until 1961. This plant may be demolished in 1974. (10)

The arsenic plant was constructed about 1918 and its use discontinued in 1964 (10).

D. Sulfur Dioxide Control Techniques

In this section, the information on control techniques was taken directly from the U. S. Environmental Protection Agency (EPA) document "Background Information-Proposed New Source Performance Standards for Primary Copper, Zinc and Lead Smelters" (11). Notations as to the sources of materials for this document have been deleted from the quotes.

The control techniques presented in this section are by no means the only techniques available. Perhaps fifty processes and their variations are available for control of sulfur oxide emissions (11). Mr. Konrad Semrau described the smelter situation quite well in a presentation at the American Chemical Society meeting in Los Angeles on April 4-5, 1974 (16). He wrote:

> "In the United States itself, control developments have consisted mainly of adoption or adaptation of systems or techniques pioneered abroad. The capability for a high degree of control by lead and zinc smelters is acknowledged, but with respect to copper smelters, continuing disputes center on the availability of control methods for dilute gases from reverberatory furnaces and the alleged impracticality of attaining 90% or greater control of emissions from complete smelters. Inasmuch as both objectives have been attained at copper smelters abroad and are now being approached in some installations in the United States, the disputes must be regarded as more political than technical in origin."

The techniques discussed in this document are considered to be the best of all those available for control of sulfur oxide emissions from copper smelters. A discussion of all the processes available is beyond the scope of this document.

4.1 Sulfuric Acid Plants

4.1.1 Summary

> "The most common technique for control of emissions of sulfur oxides from copper, lead, and zinc smelters is catalytic oxidation of sulfur dioxide in the smelter off-gases to sulfur trioxide for the production of sulfuric acid. Contact sulfuric acid plants can be designed to produce acid from gas streams containing from a fraction of a percent of sulfur dioxide up to the highest concentrations feasible in smelting operations. However, economic considerations usually restrict the applications to concentrations (> 3% or 4%) which allows autogenous operation.

"Sulfuric acid mist and smelter off-gas contaminants can present difficulties in the production of sulfuric acid due to corrosion of heat exchanger tubes, plugging of catalytic beds, or partial deactivation of the catalyst. These difficulties can be minimized by adequate design and proper maintenance of the gas purification system and the acid plant. However, an EPA analysis indicates that a 30% increase in sulfur dioxide emissions can occur due to catalyst deterioration between annual catalyst screenings.

"It is widely accepted that fluctuations in inlet volumetric flow rates and sulfur dioxide concentrations adversely affect sulfur dioxide emissions from sulfuric acid plants, although no data exists to quantify these affects. An EPA analysis, however, indicates that averaging sulfur dioxide emissions over a time period of six hours effectively masks normal short-term fluctuations in sulfur dioxide emissions.

"Sulfuric acid plant vendors guarantee maximum sulfur dioxide emission concentrations of 2000 ppm for metallurgical single-stage absorption plants and 500 ppm for metallurgical dual-stage absorption plants during three to five-day new plant performance tests. These guarantees are for maximum sulfur dioxide emissions and include inherent allowances for increased emissions due to inlet sulfur dioxide fluctuations. However, these guarantees do not include allowances for increased emissions due to catalyst deterioration.

"Manufacturers of acid mist eliminators guarantee maximum stack emissions of 1 mg/ft^3 for high efficiency acid mist eliminators. These manufacturers do not guarantee any form of visible emission limitation, but acid mist emissions of 1 mg/ft^3 normally result in stack plumes of less than 10% opacity. Thus, present control technology is adequate to restrict acid mist emissions to low opacity wisps, except during infrequent upsets."

4.1.2 General Discussion

"The basic steps in the contact process for the manufacture of sulfuric acid from sulfur dioxide-bearing gases are shown schematically in Figure 4.1. The off-gases are cooled and cleaned to remove particulates and volatile metals, acid mist is removed in an electrostatic mist precipitator and the gases are dried with 93% sulfuric acid. The cool, dry gases then pass through a series of gas-to-gas heat exchangers to heat the off-gases to the optimum temperatures for catalytic conversion of sulfur dioxide to sulfur trioxide (SO_3). Single-stage absorption acid plants use three or four stages of converter catalyst, whereas dual stage absorption plants use one, two, or three stages of catalyst before the first absorption tower. Since the conversion of sulfur dioxide to sulfur trioxide is exothermic, the converter outlet gases must be cooled before passing through the absorption tower. These outlet gases are passed countercurrent to the inlet gases in the heat exchangers mentioned above. The sulfur trioxide is then absorbed by 98% sulfuric acid in an absorption tower to yield the product. The remaining gases are then treated to remove acid mist and spray, and vented to the atmosphere if a single-stage absorption acid plant is employed. In a dual-stage absorption acid plant, the gases exhausted by the first absorption tower are passed through a second series of heat exchangers and catalytic

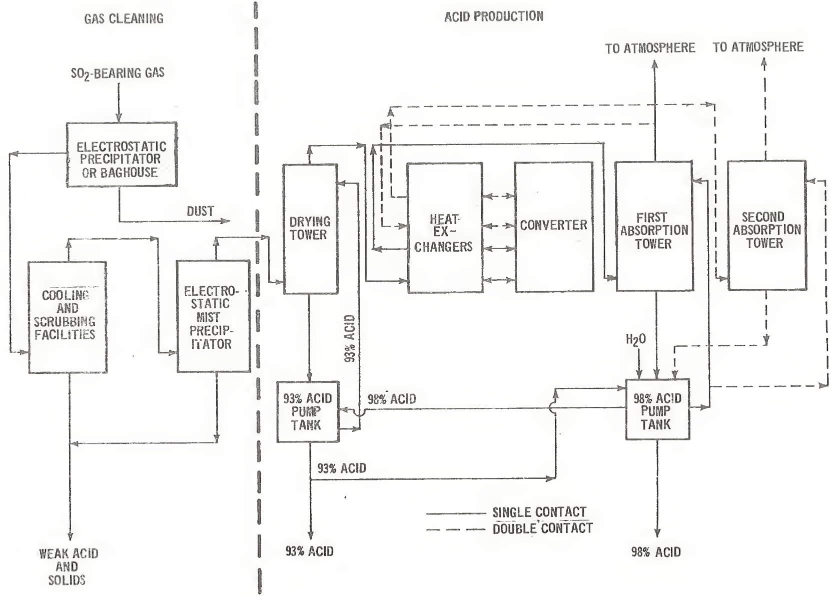


Figure 4-1 Sulfuric acid plant.

trioxide (SO_3). Single-stage absorption acid plants use three or four stages of converter catalyst, whereas dual-stage absorption plants use one, two, or three stages of catalyst before the first absorption tower. Since the conversion of sulfur dioxide to sulfur trioxide is exothermic, the converter outlet gases must be cooled before passing through the absorption tower. These outlet gases are passed countercurrent to the inlet gases in the heat exchangers mentioned above. The sulfur trioxide is then absorbed by 98% sulfuric acid in an absorption tower to yield the product. The remaining gases are then treated to remove acid mist and spray, and vented to the atmosphere if a single-stage absorption acid plant is employed. In a dual-stage absorption acid plant, the gases exhausted by the first absorption tower are passed through a second series of heat exchangers and catalytic converter stages to oxidize the sulfur dioxide remaining in the gases. Normally, this step employs one or two stages of catalyst. The gases then pass through a second absorption tower, where sulfur trioxide is absorbed by sulfuric acid as in the first absorption tower. The waste gases are then treated to remove acid mist and spray, and vented to the atmosphere.

Specific design parameters, such as the number of converter stages, catalyst inlet and outlet gas temperatures, and the degree of sulfur dioxide conversion in each catalyst stage, are based on reaction kinetics and equilibrium considerations. In dual-stage absorption acid plants, the removal of sulfur trioxide in the first absorption tower shifts the sulfur dioxide/sulfur trioxide equilibrium in favor of formation of converter stages to oxidize the sulfur dioxide remaining in the gases. Normally, this step employs one or two stages of catalyst. The gases then pass through a second absorption tower where sulfur trioxide is absorbed by sulfuric acid as in the first absorption tower. The waste gases are then treated to remove acid mist and spray, and vented to the atmosphere.

"Specific design parameters, such as the number of converter stages, catalyst inlet and outlet gas temperatures, and the degree of sulfur dioxide conversion in each catalyst stage, are based on reaction kinetics and equilibrium considerations. In dual-stage absorption acid plants, the removal of sulfur trioxide in the first absorption tower shifts the sulfur dioxide/sulfur trioxide equilibrium in favor of formation of more sulfur trioxide and results in significantly less unconverted sulfur dioxide.

"Although a gas stream containing more than 3½% sulfur dioxide is a prime consideration for acid production in single-stage absorption acid plants and a gas stream containing more than 4% sulfur dioxide is a prime consideration in dual-stage absorption acid plants, these considerations are not due to technical limitations. Contact sulfuric acid plants can be designed to produce acid from gases containing a fraction of a percent of sulfur dioxide. Economic considerations, however, usually restrict the applications to higher concentrations, since operating costs rise rapidly as the concentration of sulfur dioxide decreases.

"From mid-1971 until the end of 1972, however, the Onahama Smelting and Refining Company copper smelter in Japan produced concentrated sulfuric acidfrom the off-gases of a green-charged reverberatory smelting furnace. At this smelter, a pre-existing single-stage sulfuric acid plant was redesigned to treat weak sulfur dioxide off-gases as low as 1.5% sulfur dioxide (averaging 2.5% sulfur dioxide), while maintaining a conversion efficiency of almost 97%. Operation on such low sulfur dioxide concentrations required that the smelting furnace off-gases be refrigerated to approximately 15°C and dried to prevent exorbitant dilution of the product acid. The cooled and dried gas then required reheating to maintain optimum catalyst converter temperatures.

"Although this acid plant is no longer in operation, it was not shut down as a result of technical problems that developed. Onahama Smelting and Refining expanded the smelter by the construction of an additional reverberatory smelting furnace and additional copper converters. The acid plant now controls sulfur dioxide emissions from the new copper converters. A prototype magnesium oxide (MgO) gas scrubbing system, developed by Onahama Smelting and Refining, controls sulfur dioxide emissions from the reverberatory smelting furnaces.

"Gases containing less than 4% sulfur dioxide frequently require extra cooling in the gas purification system to remove excessive water vapor, and gases containing less than 3% sulfur dioxide frequently require refrigeration to condense enough water to obtain an acceptable water/sulfur ratio. A low water/sulfur ratio in the gases is necessary since excessive water remaining in the gas will cause dilution of the product acid below commercial grade strength.

"Single-stage sulfuric acid plants are not able to operate autothermally on off-gas streams containing less than 3½% sulfur dioxide, and dual-stage absorption acid plants require off-gases with a sulfur dioxide concentration somewhat higher (about 4%) to operate autothermally. Acid plants normally contain fired heaters for start-up operation. However, if off-gases containing less than 3½% sulfur dioxide, or 4% sulfur dioxide in the case of dual-stage acid plants, are processed on a continuous basis, large fired heaters for continuous operation to heat the gases to the temperatures necessary to obtain rapid and effective conversion of sulfur dioxide to sulfur trioxide must be incorporated.

"On the other hand, gases with sulfur dioxide concentrations of 7% or more usually do not contain sufficient oxygen for the conversion of sulfur dioxide to sulfur trioxide. It is necessary to dilute these gases with air or other off-gases containing excess oxygen before the gases enter the acid plant converters to provide the proper ratio of oxygen to sulfur dioxide.

"For maximum operating efficiency, metallurgical sulfuric acid plants should operate on a gas stream of uniform flow rate and sulfur dioxide concentration, such as those from roasters or smelting furnaces. Gas streams of fluctuating flow rates and sulfur dioxide concentrations, such as those from copper converters, require acid plants to be designed for the worst conditions and with adequate controls to handle variations in sulfur dioxide concentrations. Variations in feed gas volume are less of a problem and can be tolerated within reasonable limits.

"In order to reduce the cost of sulfur recovery, proper design necessitates that gas volumes be minimized and sulfur dioxide concentrations be maximized as much as is practical. Effective methods of increasing the sulfur dioxide concentration include oxygen enrichment of combustion air and the reduction of air infiltration by using tight-fitting hoods. Use of such methods increased the sulfur dioxide content of the off-gases from the Onahama reverberatory smelting furnace previously mentioned by approximately 50%.

"The presence of high levels of solid or gaseous contaminants in smelter off-gases can present difficulties in the production of sulfuric acid. In general, these contaminants are removed from the gas stream prior to the catalyst converters. Their reclamation represents an economic recovery or prevents damage to the acid plant or contamination of the product acid. The off-gases from smelting operations contain varying amounts of entrained dust as well as fumes formed by vaporization and subsequent condensation of volatile components. This includes compounds of arsenic, antimony, cadmium, mercury, etc., in addition to copper, lead, and zinc.

"Most of the dust and fume is recovered in dry-type collectors, such as cyclones, electrostatic dust precipitators, and baghouses, for its economic value. However, in many cases, additional cleaning is required to remove residual quantities in order to protect the acid plant. The major problems caused by these residual quantities include plugging of the catalyst beds with deactivation of the catalyst and contamination of the product acid. Chlorine and fluorine attack of stainless steels and perforation of lead sheathing by small amounts of mercury also present difficulties. However, anticipation of the potential magnitude of these problems, followed by installation of adequately designed gas cleaning systems, will ensure reduction of the concentrations to tolerable levels.

"Table 4.1 contains estimates of the maximum levels of impurities that can be tolerated in smelter off-gases. The degree of catalyst deterioration experienced at these various impurity levels can be accommodated by an acid plant which shuts down once per year to screen the catalyst and repair equipment. Table 4.1 also contains the estimated upper level of impurities that can be removed by typical gas purification systems with prior coarse dust removal. Although complete removal of contaminants from the off-gases is not practical, 99.5 to 99.9% overall removal is considered to be attainable. For especially severe cases of contamination, more elaborate cleaning systems must be designed specifically for the problem contaminants. The details vary with the contaminants but the general solution includes the use of more efficient dust or mist collectors and the scrubbing of the gases with liquids which absorb the contaminants.

"Although it is widely accepted that metallurgical off-gas contaminants can lead to plugging of the catalyst beds or partial deactivation of the catalyst, there exists a general lack of substantial numerical qualification of the effect of catalyst deterioration on sulfur dioxide emissions from metallurgical sulfuric acid plants. Sulfur dioxide emission data gathered by simultaneous EPA source testing of the No. 6 and No. 7 single-stage acid plants at the Kennecott Garfield smelter during the period of June 13-16, 1972, however, indicate that normal catalyst deterioration can result in a 30% increase in sulfur dioxide emissions."

"At the time of the EPA source testing, the No. 6 (Parsons) plant was in the second month of its twelve-month catalyst cleaning cycle and the No. 7 (Monsanto) plant was in the twelfth and last month of its catalyst cleaning cycle. A statistical analysis of the emission data leads to the conclusion that the 30% greater average emissions of the No. 7 plant, compared to the average emissions of the No. 6 plant, are statistically significant at the 90% probability level. This difference in emissions reflects not only catalyst deterioration but also other factors, such as differences in emissions due to design or construction variations between Parsons 1967 acid plant technology and Monsanto 1970 acid plant technology. However, it is safe to assume that the major portion of this difference in emissions is due to catalyst deterioation.

"Although additional data are not available, metallurgical sulfuric acid plant vendors have agreed that the EPA estimate of a 30% increase in SO_2 emission concentrations as the upper limit for deterioration of catalyst performance between catalyst screenings for single-stage acid plant is also a reasonable estimate for dual-stage acid plants. The period between catalyst screenings is primarily a function of pressure drop rather than conversion efficiency. Generally, the first bed depth

Table 4-1 ESTIMATED MAXIMUM IMPURITY LIMITS FOR METALLURGICAL OFF-GASES USED TO MANUFACTURE SULFURIC ACID[10]

Substance	Approximate Limit, (Mg/Nm^3)[a] Acid Plant Inlet	Gas Purification System Inlet[b]
Chlorides, as Cl	1.2	125[d]
Fluorides, as F	0.25	25[e]
Arsenic, as AS_2O_3	1.2[c]	200
Lead, as Pb	1.2	200
Mercury, as Hg	0.25	2.5[f]
Selenium, as Se	50[c]	100
Total Solids	1.2	1000[g]
H_2SO_4 Mist, as 100% acid	50	-
Water, as H_2O	-	400×10^3

Notes:

(a) Basis: dry off-gas stream containing 7% sulfur dioxide.

(b) For a typical gas purification system with prior coarse dust removal.

(c) Can be objectionable in product acid.

(d) Must be reduced to 6 if stainless steel is used.

(e) Can be increased to 500 if silica products in scrubbing towers are replaced by carbon; must be reduced if stainless steel is used.

(f) Can be increased to 5-12 if lead ducts and precipitator bottoms are not used.

(g) Can usually be increased to 5000-10,000 if weak acid settling tanks are used.

Although it is widely accepted that metallurgical off-gas contaminants can lead to plugging of the catalyst beds or partial deactivation of the catalyst, there exists a general lack of substantial numerical qualification of the effect of catalyst deterioration on sulfur dioxide emissions from metallurgical sulfuric acid plants. Sulfur dioxide emission data gathered by simultaneous EPA source testing of the No. 6 and No. 7 single-stage acid plants at the Kennecott Garfield smelter during the period of June 13-16, 1972, however, indicate that normal catalyst deterioration can result in a 30% increase in sulfur dioxide emissions.[8] A summary of this analysis is included in Appendix III.

At the time of the EPA source testing, the No. 6 (Parsons) plant was in the second month of its twelve-month catalyst cleaning cycle and the No. 7 (Monsanto) plant was in the twelfth and last month of its catalyst cleaning cycle. A statistical analysis of the emission data leads to the conclusion that the 30% greater average emissions of the No. 7 plant, compared to the average emissions of the No. 6 plant, are statistically significant at the 90% probability level. This difference in emissions reflects not only catalyst deterioration but also other factors, such as differences in emissions due to design or construction variations between Parsons 1967 acid plant technology and Monsanto 1970 acid plant technology. However, it is safe to assume that the major portion of this difference in emissions is due to catalyst deterioration.

is 50% greater than the theoretical design depth in order to compensate for the anticipated decrease in conversion efficiency as the catalyst becomes partially plugged and the pressure drop increases between catalyst screenings. Catalysts are guaranteed for various periods although longer guarantees necessitate the use of more catalyst for a larger conversion efficiency margin. The screening period varies from one year to two years depending upon blower capacity and the particulate collection efficiency of the gas purification equipment. As a rule of thumb, for an application in which the catalyst is not subject to poisoning, the catalyst in the first bed should be replaced after 10-12 years if performance has deteriorated.

"Acid plant vendor guarantees are based on new plant performance and do not include a margin for increases in emissions due to catalyst or plant deterioration with age. Furthermore, these guarantees are for acid plant performance only and obviously do not include smelter emissions which are bypassed to the atmosphere during periods of acid plant shutdown for catalyst screening and/or replacement or other plant maintenance.

"In some cases, trace amounts of contaminants can pass through both the gas cleaning equipment and the catalyst to contaminate the product acid. In these cases, the acid can either be sold to outlets that are not sensitive to the contamination, cleaned of the objectionable contamination, or neutralized and disposed of. The production of dark, discolored acid ("black acid") is a common example of acid contamination. Frequently, within multi-hearth roasters or lead sintering machines, various organic agents entrained with the concentrates are merely vaporized or only partially decomposed. Trace amounts of these organic agents can pass through both the gas cleaning equipment and the catalyst and be captured in the product acid leading to the production of "black acid."

"Normally, within fluid-bed roasters, however, these organic flotation agents are completely decomposed and thus sulfuric acid produced from these off-gases is free of organic contaminants. Although there are techniques which can be used to purify or bleach acid, these techniques are usually costly and sometimes are not entirely satisfactory. For example, oxidation of the organic contaminants by hydrogen peroxide is accompanied by the release of water which dilutes the product acid. Similarly, the use of potassium permanganate results in the contamination of the acid by manganese ions which can be objectionable in some processes. Experiments have been conducted using ozone as the oxidizing agent and the results are promising. However, there are outlets for sulfuric acid which are not sensitive to color, such as the production of fertilizers or alkylation processes at refineries.

"Contamination of product sulfuric acid by other contaminants, such as mercury, cadmium or arsenic, etc., can also occur. In general, these contaminants are more difficult to remove from the product acid and present greater problems than the production of "black acid". Although the Bunker Hill Company recently announced development of a process capable of reducing mercury levels in sulfuric acid from100 ppm to 1 ppm [sic].

"Depending upon the amount of excess oxygen, the temperature, and the presence of metallic oxide particulates in the off-gases, some sulfur trioxide is formed during the various smelting operations. In the presence of water or weak acid vapors, sulfur trioxide forms sulfuric acid mist at temperatures of less than 200°C. If not removed, the mist particles will cause corrosion problems and the iron sulfates resulting from corrosion can be deposited on the catalyst. Heat exchanger corrosion is serious, not only because of the physical damage to the equipment, but also because leaks will result in a substantial increase in the concentration of sulfur dioxide contained in the gas stream to the final absorber. This sulfur dioxide is not absorbed and is emitted to the atmosphere.

"Sulfuric acid mist particles are extremely difficult to remove from the gas stream, and special equipment, such as electrostatic mist precipitators, are required. To guard against small amounts of dust or mist which can be carried through precipitators due to flow surges or other troubles, a fiber bed filter, such as the Brink Mist Eliminator, can be used as a backup device. Although maintenance benefits and corresponding sulfur dioxide emission abatement benefits can be realized by using fiber bed filters ahead of heat exchangers and catalyst stages, such installations are still infrequent. However, fiber filters have been widely accepted for removal of sulfuric acid mist from absorber effluents, and they can be utilized to protect process equipment. In general, by adequate plant design and proper maintenance, the effects of corrosion due to acid mist can be minimized. Furthermore, due to the use of special linings, demisters, and special alloy heat exchanger tubes, sulfuric acid plants are currently being designed to have extremely long life and low maintenance.

"Acid mist emissions from dual-stage sulfuric acid plants are normally less than acid mist emissions from single-stage acid plants because the mist loading of the final absorbing tower is less. However, an acid mist eliminator must be installed following the first absorption tower in dual-stage acid plants to protect downstream equipment from corrosion. Absorption towers have inherent lags and are extremely sensitive to many variables including inlet sulfur trioxide concentration, absorbing acid strength, temperature, and flow rate. However, present control technology is adequate to restrict acid mist emissions to low opacity wisps, except for infrequent upsets. Such upsets are caused by the absorbing sulfuric acid concentration becoming greater than azeotropic and thus allowing sulfur trioxide to remain unabsorbed by the acid and create a visible acid mist plume as it combines with water after leaving the stack. Mist eliminators are particulate collection devices and obviously cannot prevent acid mist emissions produced during upsets by combination of sulfur trioxide emissions with water after leaving the mist eliminator.

"Manufacturers of mist eliminators guarantee maximum stack emissions of 1 mg/ft^3 for high-efficiency mist eliminators and 2 mg/ft^3 for lower efficiency models. Mist emissions are normally less than 50% of the guaranteed value. Under worst conditions the 2 mg/ft^3 emission value can represent a 20% opaque plume, but normally the emissions from a high-efficiency mist eliminator are less than 10% opacity.

> "Typically, sulfuric acid plant vendors guarantee maximum sulfur dioxide emission concentrations of 2000 ppm for metallurgical single-stage absorption plants and 500 ppm for metallurgical dual-stage absorption plants during new plant performance tests. Such tests are conducted for three to five consecutive days while the plant is operating on gases that contain the percentages of sulfur dioxide specified in the design basis for the plant and while the plant is not experiencing any malfunctions. It is significant to note that these guarantees are for maximum sulfur dioxide emissions and thus include inherent allowances for increased emissions due to inlet sulfur dioxide fluctuations. Although these guarantees are for new plants and do not include allowances for increases in emissions due to catalyst or plant deterioration with age, one domestic vendor does guarantee these emission levels for one year after start-up.
>
> "An EPA analysis of approximately ten weeks of emission data from one of the Kennecott Copper Corporation single-stage sulfuric acid plants at Garfield, Utah, showed sulfur dioxide emissions during normal operations of less than 2000 ppm when averaged for long periods, such as one week. The specification of 'normal' operations was determined by analyzing acid plant operating logs and inlet flow rate and sulfur dioxide concentration data to ascertain the extent of malfunctions and startup and shutdowns during the period. It is significant to note that the long term average SO_2 concentration value is considerably less than the emission concentration (2700 ppm) corresponding to the vendor guarantee of 95% conversion at 5% SO_2 inlet.
>
> " . . . for maximum operating efficiency metallurgical sulfuric acid plants should operate on gas streams of uniform flow rate and sulfur dioxide concentration. However, off-gases from some smelting operations, such as copper converting, exhibit extreme fluctuations in both volumetric flow rate and sulfur dioxide concentration."
>
> "The use of sulfuric acid plants to control sulfur dioxide emissions from copper, lead and zinc smelters is well demonstrated technology. As discussed in Section 5 of this document, six of the fifteen domestic copper smelters produce sulfuric acid from process off-gases."

As mentioned at the end of Section II C above, three sulfuric acid plants at the Anaconda smelter are now idle but are probably still operable. If these three plants, with their total acid capacity of 450 T./day could be used to treat the present smelter off-gases, the overall sulfur control capability at the smelter could increase from the present 37% to about 62%. Modifying the recently installed sulfuric acid plant from 660 to 990 T./day, plus reactivating the three older plants could provide an overall smelter sulfur retention of about 80% and an acid making capacity that would total 1440 T./day.

The usefulness of the three older plants would depend on many factors. They were designed for gas streams richer in sulfur dioxide than is now produced at the smelter and would require concentration of the sulfur oxides in the reverberatory gases. However, the sulfur oxide gases from the proposed new fluo-solid roaster and electric furnace may be of sufficient concentration for introduction into these older acid plants. There are neither ducts between the existing flue system and these older plants nor systems for moving the product acid to the load-out facility. These problems are not insurmountable and solving them could possibly lead to use of already existing structures and facilities, which would not require new capital construction outlay. The Company may have reasons for not reactivating the older plants that are not known by the Department of Health and Environmental Sciences. The 1971 program submitted by the Company that has since been revised indicated the Company preferred to install new acid plant capacity rather than put the older plants back in service.

Neutralization of smelter produced sulfuric acid may berequired if ready markets or uses for it are not found. As of this time neutralization has not been employed by any smelter on a significant basis. Expected increased demand for sulfur may lead to new market development. Even existing markets for the cheap sulfuric acid can be expected to expand. It should also be pointed out that production of sulfuric acid and the resultant neutralization of excess production is not a foregone conclusion but would be the result of a decision by the company. Other methods of sulfur oxide control are available which avoid the possibility of having to neutralize sulfuric acid. These methods are discussed in this section. However, since neutralization is one possible aspect of sulfur oxide control by the sulfuric acid production method, a brief description of the process follows in Section II E.

4.2 Elemental Sulfur Plants

4.2.1 Summary

> "Elemental sulfur plants have never achieved widespread use within the copper, lead or zinc smelting industry. However, in some cases they represent a viable alternative to the production of sulfuric acid from sulfur dioxide emissions contained in various smelter off-gases. Three companies have developed or are actively developing sulfur dioxide reduction technology: Allied Chemical Corp. and American Smelting and Refining Co./Phelps-Dodge Corp. (ASARCO/PD) in the United States and Outokumpu Oy in Finland. Both Allied Chemical and Outokumpu have announced the commercial availability of their technology. ASARCO/PD, however, is still in the pilot plant stage of development.
>
> "The Allied Chemical and ASARCO/PD technology is generally applicable to the wide range of smelter off-gases. The Outokumpu technology, however, is restricted to flash smelting furnaces.
>
> "Of the various off-gases generated during the smelting of copper, lead or zinc, only those discharged by fluid-bed roasters and flash smelting furnaces are suitable for direct application of sulfur dioxide reduction technology. Off-gases discharged by other process units require concentration of the sulfur dioxide in a regenerative off-gas desulfurization system prior to reduction.
>
> "There exists little data from which a quantitative conclusion can be drawn regarding the increase in sulfur dioxide emissions from elemental sulfur plants due to normal catalyst deterioration. However, review of the limited data available indicates that 5-10% increase in emissions is likely to occur between annual plant turnarounds as a result of catalyst deterioation.
>
> "Elemental sulfur plants normally achieve sulfur dioxide reduction efficiencies of 90%. The concentration of sulfur dioxide in the tail gases released to the atmosphere is normally in the range of 0.7-1.0% if the plant operates on the off-gases from a fluid-bed roaster or flash smelting furnace. If the plant operates on a sulfur dioxide process gas produced by a regenerative off-gas desulfurization process, the concentration of sulfur dioxide in the tail gas released to the atmosphere is normally in the range of 2-5%."

Several processes for clean-up of tail gas streams from elemental sulfur plants are available. These include Wellman and Beavon Sulfur Removal Process.

4.2.2 General Discussion

> "Although elemental sulfur plants have never achieved widespread use within the copper, lead or zinc smelting industry, the recovery of elemental sulfur from smelter off-gases has generated a great deal of interest, as evidenced by the number of elemental sulfur plants that have operated throughout the world during the past forty years. The failure of this technology to achieve widespread application in most cases has not been due to technical limitations, but a matter of economics where other alternatives have been available.

"Essentially, elemental sulfur plants consist of two basic process steps. A fossil fuel is mixed with the gas stream to be reduced, frequently in the presence of a catalyst to promote the reduction reactions. A portion of the sulfur dioxide in the gas stream is reduced to elemental sulfur and hydrogen sulfide. The extent to which elemental sulfur and hydrogen sulfide are formed and sulfur dioxide remains in the gas stream depends on temperature, pressure and the carbon to hydrogen ratio in the fuel utilized as a reductant. With the reductant properly proportioned to the sulfur dioxide in the gas stream, the ratio of hydrogen sulfide to sulfur dioxide remaining will be approximately 2:1. Following reduction, a Claus catalyst is utilized to react the hydrogen sulfide formed with the remaining sulfur dioxide, producing elemental sulfur according to the familiar Claus reaction:

$$4H_2S + 2SO_2 \rightarrow 3S_2 + 4H_2O$$

"The reductant employed in elemental sulfur plants can be coke, pulverized coal, fuel oil, natural gas or reformed natural gas. Natural gas or fuel oil, however, is frequently the choice of reductant where available, as a minimum of facilities for introduction and admixture into the gas stream to be reduced are required.

"Currently, three companies have developed or are actively developing sulfur dioxide reduction technology for direct application to copper, lead or zinc smelters: Allied Chemical Corp. and American Smelting and Refining Co/Phelps Dodge Corp. (ASARCO/PD) in the United States and Outokumpu Oy in Finland. Although both Allied Chemical and Outokumpu have announced the commercial availability of their technologies, ASARCO/PD is still in the pilot-plant stage of development."

Figure 4-X and 4-Y illustrate the two commercially available elemental sulfur processes.

4.3 Scrubbing Systems

"Historically, there has been little economic incentive to desulfurize process off-gases containing sulfur dioxide in concentrations ranging from 0.05 to 3.5 percent. Process off-gases from fossil fuel-fired power plants, refinery sulfur recovery plants, sulfuric acid plants, and certain smelter process equipment such as reverberatory furnaces and sintering machines are included in this category. Until recently, there has been little demonstrated control of sulfur dioxide from these sources, except in areas affected by severe air pollution problems. The approach utilized to control sulfur dioxide in most instances has been to employ scrubbing systems to chemically react the SO_2 with liquid phase absorbents to yield sulfur compounds that can be either discarded, reprocessed, or sold directly as obtained for use in other industries. The term 'scrubbing systems' has come into common usage when describing such chemical processes since each of the systems required the use of process equipment; i.e., a scrubber to promote gas phase mass transfer and/or chemical reaction rate.

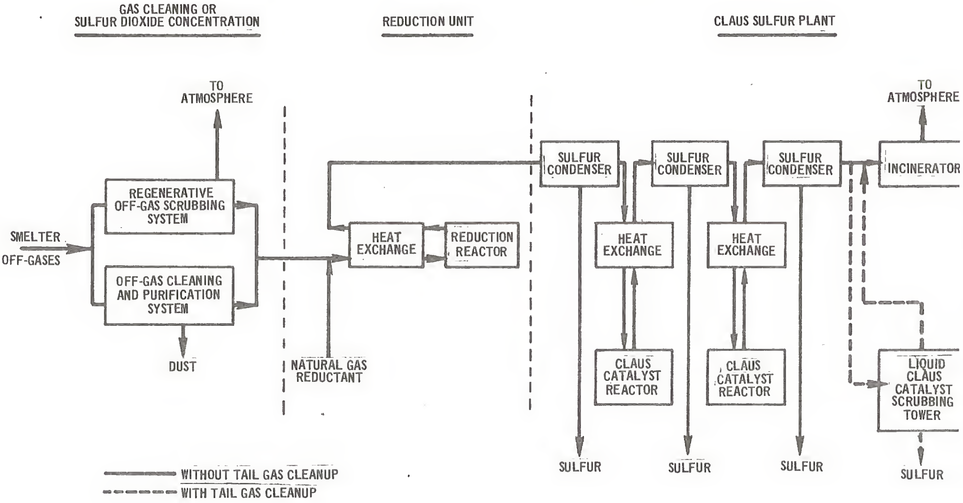


Figure 4-X. Allied Chemical Sulfur Dioxide Reduction Process.

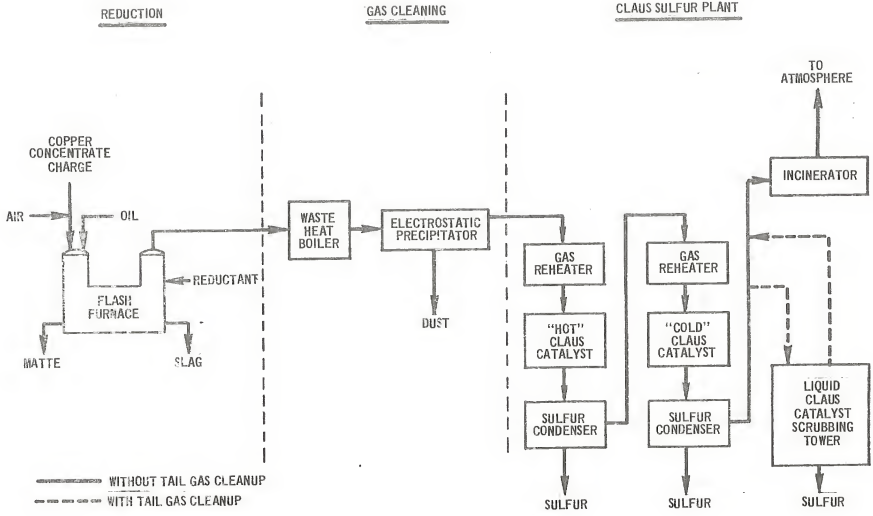


Figure 4-Y. Outokumpu Sulfur Dioxide Reduction Process.

"There are three major variations of scrubbing systems where the reactant is added to the scrubbing media as indicated below:

1. Non-cyclic system - This open-loop type of system has a throwaway product. The liquor stream has only one pass through the scrubber.

2. Cyclic-non regenerative system - This closed-loop type of system has a large percentage of the removed sulfur contained in a throwaway or salable product. As much as possible of the liquor stream is recycled through the scrubber. Depending on the process, SO_2 may or may not be recovered.

3. Cyclic-regenerative system - This closed-loop type of system recovers SO_2 and has a relatively small waste product for disposal. The absorbent is regenerated and the liquor stream recycled through the scrubber.

"The nature of metallurgical process off-gases is somewhat unique in that a wide variety of contaminants are included in the effluent stream along with sulfur dioxide. The presence of high concentrations of oxygen (relative to fossil-fuel-fired power generating plants), particulates, acid gases, metallic fumes, and high gas temperatures could cause chemical or mechanical problems with cyclic absorption systems. In most cyclic systems, pretreatment of the process off-gases would be required prior to absorption of the sulfur dioxide in the scrubbing media.

"During the past forty years, over fifty process schemes utilizing various types of absorbent as a scrubbing media have been investigated on a bench scale, pilot plant, or prototype basis in an effort to perfect the optimum control for low concentrations of sulfur dioxide in process off-gases. As a result of these efforts, at least two processes have emerged as worthy of commercial application in the control of low concentrations of sulfur dioxide in process off-gases from primary copper, lead and zinc smelters. These are the Cominco ammonia absorption process and the ASARCO DMA process. Two other processes that have had commercial application in the control of SO_2 from either fossil-fuel-fired power plants, sulfur recovery plants or sulfuric acid plants and are considered to have high potential in the control of low concentrations of SO_2 from smelter processes are calcium-based absorption systems and sodium sulfite-bisulfite absorption systems."

4.3.1 Calcium-Based Scrubbing Systems

"Calcium-based scrubbing systems may be of the non-cyclic type or of the cyclic-nonregenerative type. In the non-cycle system, the absorbent passes through the scrubber on a once-trhough basis. Early work on this type of system was conducted by the London Power Company in the 1930's, alkaline Thames River water provided the absorbent. This type of system has inherent water pollution problems in some situations that would preclude its usage on a wide scale.

"Also in the 1930's, technology was developed on cyclic-nonregenerative scrubbing systems. Lime-limestone (calcium based) processes were used on a commercial scale at the Fulham Power Station in England to control SO_2 emissions from power plant off-gases."

Summary

"There are no known installations of calcium-based scrubbing systems installed to control sulfur dioxide emissions from either domestic or foreign primary copper, lead or zinc smelters. However, facilities have been installed to control sulfur dioxide emissions from fossil-fuel-fired power plants, as well as a molybdenum ore roaster, a secondary lead smelter, and an iron ore sintering plant. All of these applications control process off-gases that have sulfur dioxide concentrations of less than 0.6 percent (6000 ppm). Although the smelter industry has not chosen to install calcium-based scrubbers to date, it is pointed out that the use of calcium-based scrubbers to control sulfur dioxide from weak streams (0.6 to 3.0 percent) from primary copper, lead and zinc smelters has been suggested by organizations and individuals as documented below:

1. Arthur G. McKee & Company - in a report prepared for the Environmental Protection Agency, 1969.
2. The U. S. Bureau of Mines - in a report prepared to evaluate control of sulfur oxide emissions in copper, lead and zinc smelting, 1971.
3. Konrad T. Semrau, associated with Stanford Research Institute, in papers published in the Journal of the Air Pollution Control Association, 1971 and in the Journal of Metals, 1971.
4. Responsible control equipment vendors with years of research and experience with calcium-based scrubbing systems have indicated that higher concentrations of sulfur dioxide would not present unsurmountable operational problems."

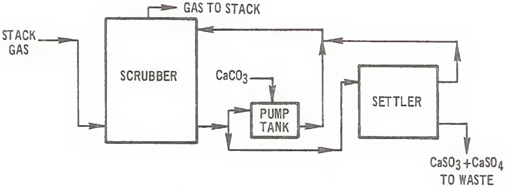
Figure 4-2 illustrates the lime/limestone scrubbing process. Section II E below describes some of the possible secondary pollution problems.

4.3.2 Dimethylaniline (DMA) Scrubbing

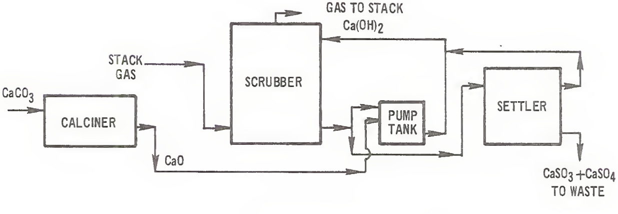
Summary

"The American Smelting and Refining Company dimethylaniline (DMA) process has been used to recover sulfur dioxide from smelter gases containing 4 to 10 percent sulfur dioxide. The process has been utilized to recover sulfur dioxide included in process off-gases emanating from Dwight-Lloyd lead sintering machines, and blended effluents from copper smelter roasters, reverberatory furnaces, and converters.

"A new DMA system was put into service in November, 1972, by Phelps-Dodge Corporation at Ajo, Arizona to recover sulfur dioxide from copper



Scrubber addition of limestone.[6]



Scrubber addition of lime.[6]

Figure 4-2 Limestone/lime scrubbing processes.

smelter reverberatory furnace and converter process off-gases. The system is reportedly designed to process reverberatory furnace off-gases with sulfur dioxide concentrations ranging from 1½ to 2 percent although proportional valving is installed so that converter gas can also be fed to the system. Although insufficient data are presently available to evaluate the Ajo facility when operated on copper smelter reverberatory furnace off-gases alone, it has been demonstrated in other applications that mixtures or blends of process off-gases from roasters, reverberatory furnaces and converters can upgrade the sulfur dioxide concentration of the feed stream to the DMA process so that the system can be operated in an acceptable manner.

"The equilibrium between dimethylaniline and sulfur dioxide is generally unfavorable for economic recovery of sulfur dioxide from gas streams containing less than 1.5 to 2.0 percent sulfur dioxide.

"It is concluded that the DMA absorption system is a viable process that can be utilized to control sulfur dioxide emissions from properly cleaned and conditioned smelter process off-gases that have (or can be upgraded to have) sulfur dioxide concentrations in the range of 4 to 10 percent.

"It is anticipated that the DMA system will be demonstrated in the near future for use on weak SO_2 streams from copper smelting operations."

Simplified Process Description

"The DMA absorption system is a cyclic-regenerative process. The system incorporates an absorption tower with numerous trays that allow for much greater gas phase mass transfer and reactant surface area than other scrubbers such as venturi or single-bed type. Liquid sulfur dioxide is recovered as a product, and the absorbent is regenerated and recycled through the system. A small purge stream is required to eliminate sodium sulfate (in solution) from the regenerator section. A small amount of dimethylaniline is also included in the purge stream.

"A simplified flow diagram for the dimethylaniline scrubbing system is depicted in Figure 4-3. A brief description of the process is essentially as follows. Pretreated SO_2 laden process off-gases vent to the bottom of a bubble plate scrubbing tower where most of the SO_2 is absorbed in a counter-current stream of anhydrous dimethylaniline. The gases, impoverished in sulfur dioxide and enriched in dimethylaniline vapors, then pass to a second section of the tower where they are scrubbed with a weak sodium carbonate solution. The residual SO_2 in the gases converts the sodium carbonate to sodium sulfite or sodium bisulfite. The carbon dioxide is liberated in the gas stream. The effluent gases then pass to a third section of the scrubbing tower where they are scrubbed with a weak sulfuric acid solution where entrained vaporized dimethylaniline is recovered as dimethylaniline sulfate. The effluent then vents to the atmosphere.

"Pregnant dimethylaniline is heated by exchange and then passes to the center section of a bubble plate stripping tower. The liquid flows downward countercurrent to a rising column of steam and sulfur dioxide vapors. The sulfur dioxide is stripped from the dimethylaniline

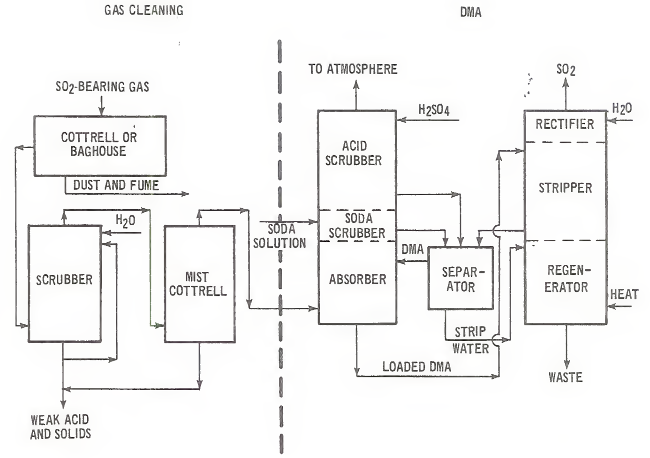


Figure 4-3 DMA Scrubbing Process.

and escapes upward through the tower. The recovered dimethylaniline is cooled and then passes to a series of separators where the absorbent floats on the water and can be physically separated and sent to the DMA surge tank for recycle.

"The aqueous effluent from the soda scrubbing and acid scrubbing sections of the absorption tower passes to a collection tank where dimethylaniline is liberated as a result of the reaction between dimethylaniline sulfate from the acid scrubber and the sodium sulfite-bisulfite from the soda scrubber. Part of the dimethylaniline remains dissolved in the water as diemthylaniline sulfite. Total water and solution added to the process empties to a stripper water tank. The water then passes to the bottom section (regenerator) of the stripping tower where the dimethylaniline sulfite is thermally decomposed and SO_2, DMA, and water are vaporized and vented into the stripper section of the tower. A small purge stream is drawn off the regenerator to remove sodium sulfate.

"The stripped SO_2 and residual DMA vapors pass from the stripping section into the top section (rectifier) of the stripping tower where they are bubbled through the water. The DMA, by reacting with SO_2 in the presence of water, is recovered as dimethylaniline sulfite and passes back to the stripper section.

"The hot sulfur dioxide is cooled, scrubbed again with cold water, and dried in a tower with 98 percent sulfuric acid. The gas is then compressed, cooked, liquified, and run to storage."

Survey of Operating Experience

"A partial list of commercial applications of ASARCO DMA sulfur dioxide absorption systems is shown in Table 4.3.

"The first domestic commercial application of the DMA absorption system was made by ASARCO in 1947 to recover sulfur dioxide from Dwight-Lloyd lead sintering machine off-gases. The lead smelter located at Selby, California is no longer in operation; however, the DMA absorption system is leased to a chemical company. The DMA plant was nominally rated at 20 tons of liquid SO_2 per day. The sulfur dioxide content of the inlet gases usually ranged from 4 to 6 percent and averaged approximately 5 percent. The sulfur dioxide concentration in the process off-gases ranged from a low of approximately 500 ppm in the winter months to as high as 3000 ppm in the summer months, depending primarily on cooling water temperature. Problems associated with materials of construction were encountered; however, these problems, in general, were satisfactorily resolved. Lead, as a material of construction, was extensively employed to eliminate corrosion.

"In 1949, the DMA process was first utilized by the Tennessee Copper Company (now Cities Service Company) at their smelter operations at Copperhill, Tennessee. The capacity of the plant was nominally rated at 30 tons of liquid SO2 per day. Subsequently, the capacity of the original plant was increased and a second DMA plant added. The two DMA plants are currently rated at 40 and 55 tons of liquid SO_2 per day, respectively. The feed stream for the DMA plant is 6 percent SO2, and

Table 4-3 ASARCO DMA installations[5D]

	Company	Process	DMA Design Capacity Liquid SO_2	SO_2 Concentration Inlet	Outlet	Remarks
1.	American Smelting and Refining Company Selby, California	Dwight-Lloyd lead sinter machine	20 T/D	4-6%	500-3000 ppm	Outlet concentration related to cooling water temperature. No longer operating on smelter off-gases.
2.	Cities Service Company Copperhill, Tennessee	Mixture of gases from iron and copper roasters, reverberatory furnaces and converters.	#1 40 T/D #2 55 T/D	$\geq$6%	2000 ppm	Two DMA units in operation.
3.	Phelps Dodge Corporation Ajo, Arizona	Copper smelter reverberatory furnace and/or converters	150 T/D	1 1/2-2%		Plant in start- phase.
4.	American Smelting and Refining Company Tacoma, Washington	Copper converters	200 T/D	3-10%		Plant under construction.

is a mixture of process off-gases from iron and copper roasters, copper reverberatory furnace and copper converters. The inlet gas to the DMA scrubber is precleaned in the same system as acid plant gas, then bled off before the acid plant absorber. The sulfur dioxide concentration of the off-gases from the DMA absorption tower approximates 3000-5000 ppm, but reportedly the absorption tower could be operated as low as 1500 ppm without requiring major modifications. The DMA plants were primarily designed to produce liquid SO_2 for market and were not built as air polltuion control devices. The only operating difficulty associated with the DMA plants is that of regulating the pH of the system. If pH control is lost, carbonation occurs causing vaporization in the pumps."

Section II E below describes some of the possible secondary pollution problems.

4.3.3 Ammonia Scrubbing Systems

"Ammonia scrubbing systems have received considerable attention in the history of SO2 removal from process off-gases. The reasons for this include relatively high affinity of ammonia solutions for SO_2 and the ability to keep all the compounds involved in solution, thereby avoiding scaling and silting problems in the scrubbers.

"The Cominco ammonia absorption process was developed by the Consolidated Mining and Smelting Company of Canada, Ltd. (Cominco) in 1936. The U. S. licensor for the process is Olin-Mathieson Chemical Corporation. Plant units have been built by Cominco in Trail, B.C., Canada to treat gases from lead and zinc smelting operations. The Olin-Mathieson Corporation has installed plants to treat the tail gases from sulfuric acid plants."

Summary

"The Cominco absorption process has been used to treat process off-gases with sulfur dioxide concentrations as low as 0.5 percent, with very good recovery. Tail gases contain as little as 0.03 percent sulfur dioxide.

"The process has been utilized to recover sulfur dioxide included in process off-gases from Dwight-Lloyd lead sintering machines, zinc roasters, and sulfuric acid plant tail gases.

"It is concluded that the Cominco process is a viable process that can be utilized to control sulfur dioxide emissions from properly cleaned and conditioned smelter process off-gases that have sulfur dioxide concentrations in the range of 0.5 to 6.0 percent."

Process Description

"A simplified description of the Cominco process is as follows (see Figure 4-4). Hot smelter off-gas is treated and conditioned prior to introduction into the first scrubbing tower. The gases are cooled,

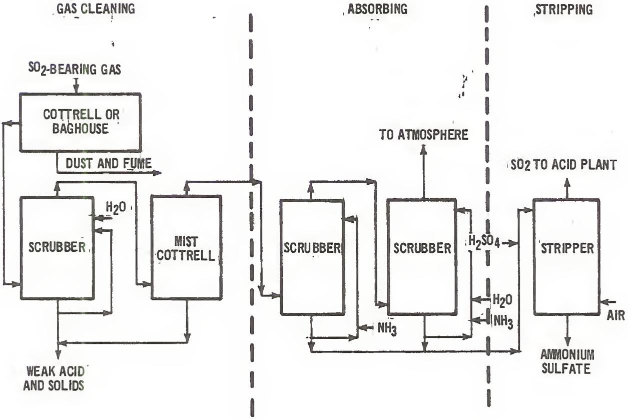


Figure 4-4 Cominco ammonia scrubbing process.

fine solids are washed out, and sulfur trioxide is absorbed to form weak sulfuric acid. The cooled off-gases then pass to the bottom of a scrubbing tower where they are contacted with a counter current flow of ammonium sulfite-bisulfite solution. The solution in the first scrubber is maintained at low pH (approximately 4.6) and high salt concentration. Sulfur dioxide is absorbed to form additional ammonium bisulfite. A portion of the solution is recycled back through the tower, and a portion of the solution from the tower is sent to the stripper.

"The partially cleaned gases then pass to a second scrubber where additional sulfur dioxide is removed by contact with an ammonium sulfite-bisulfite solution that is at a high pH (approximately 5.4) and has a low salt concentration. A portion of the scrubbing solution is recycled through the scrubber, and a portion of the solution from the tower is sent to the scrubber. The off-gas from the scrubber passes to the atmosphere.

"The bisulfite solution diverted to the stripper is acidified with sulfuric acid and stripped with air to produce about a 25 percent sulfur dioxide gas stream, and a solution of ammonium sulfate containing about 10 percent of the feed sulfur. The ammonium sulfate is then crystallized out and utilized as a fertilizer.

"If the consumption of sulfuric acid and ammonia, and the production of ammonium sulfate are not economically favorable, the sulfur dioxide can be removed from the ammonium bisulfite solution by stripping with steam. Under the name of the "exorption process," this type of system was used by Cominco during the years 1940 to 1943 permitting the recycle of 30 percent of the required ammonia. It is still considered by Cominco to be a feasible process for use under appropriate economic conditions."

Survey of Operating Experience

"A partial list of commercial applications of Cominco type ammonia scrubber systems is shown in Table 4-4."

Section II E below describes some of the possible secondary pollution problems.

4.3.4 Sodium Sulfite-Bisulfite Scrubbing

"Most of the development work on a sodium sulfite-bisulfite scrubbing system in this country has been conducted by Davy Power Gas (formerly Wellman-Lord). Davy began this development about the mid-1960's using the potassium rather than the sodium salt. One of the primary reasons given for discontinuing the use of potassium was that numerous pilot plant investigations had determined that regeneration costs were unduly high.

"A series of pilot plant tests were run prior to the first commercial installation of this process. These pilot plants ranged in size from about 600 to 50,000 scfm and were installed on a variety of sources which included coal and oil-fired steam generators and smelter processes such as converters and reverberatory furnaces."

Table 4-4 COMINCO TYPE AMMONIA SCRUBBER INSTALLATIONS

Company	Process	Volume	SO_2 Concentration		Remarks
			Inlet	Outlet	
1. Consolidated Mining and Smelting Company of Canada, Ltd. Trail, B.C., Canada[7A]	Lead sintering	200,000 SCFM	15,000 - 25,000 ppm	1200 ppm	
	Zinc flash and multihearth roasters	0-45,000 SCFM	60,000 ppm	1000 ppm	Handles excess not sent to acid plant
	Sulfuric acid plant tail gases	50,000-95,000 SCFM	5000 ppm	700 ppm	
2. Allied Chemical Corp. Newell, Pennsylvania[6A]	Sulfuric acid plant tail gases	-	3000 ppm	100 ppm	Ammonium salt solution incinerated in pyrite roaster system
3. Olin Chemical Corp. Beaumont, Texas[4A]	Sulfuric acid plant tail gases	-	3000 ppm	750 ppm	
	Sulfur recovery plant tail gases	-	20,000 ppm	2000 ppm	

Summary

"There are no known commercial sodium sulfite-bisulfite scrubbing systems installed to minimize sulfur dioxide emissions from either domestic or foreign primary copper, lead or zinc smelters; however, a number of domestic and foreign installations have been made to control tail gas emissions from sulfur recovery plants, sulfuric acid plants and oil-fired steam generators. The sulfur dioxide concentration in the process off-gases ranged from 2100 ppm to 13,000 ppm. The sulfur dioxide concentration in the Wellman-Lord absorber off-gases was 500 ppm or less.

"It is concluded that sodium sulfite-bisulfite absorption systems appear to be technically feasible to minimize sulfur dioxide emissions from primary copper, lead and zinc smelters; however, it has not been demonstrated that the absorption process can be operated to control smelter off-gases without excessive oxidation of the absorbent resulting in a required large purge stream and, consequently, high costs. Both Davy Power Gas and Japanese organizations are working hard to improve this disadvantage."

Process Description

"The Davy Power Gas scrubbing process is of the cyclic-regenerative type. Concentrated sulfur dioxide is recovered as a valuable product and the sodium sulfite-bisulfite absorbent is thermally regenerated and recycled through the system.

"A simplified flow diagram for the Davy Power Gas scrubbing system is depicted in Figure 4-5.

"As with most cyclic-regenerative absorption systems, pretreatment of the process off-gases is required if it is necessary to cool the process off-gases and to remove particulates and acid gases that may interfere with the absorptionprocess or cause problems such as corrosion and plugging or fouling of the system. This pretreatment step must be studied on a case-by-case basis to insure the selection of the optimum design in relation to the overall facility.

"The process description is essentially as follows. Pretreated SO_2 laden process off-gases are introduced into a scrubber where they are ab sorbed in a counter-current flow of a solution of sodium sulfite-bisulfite. The rich absorbent from the bottom of the scrubber is pumped to an evaporator crystallizer system where it is heated by indirect heat exchange with low pressure steam. As a result of the regeneration step, steam and SO_2 are driven off; and sodium sulfite crystals are formed in the liquid. The wet sulfur dioxide gases are run through a condenser where the bulk of the steam is removed. The concentrated SO_2 stream can be utilized in a sulfuric acid plant, a sulfur recovery plant, or some other appropriate sulfur dioxide process scheme.

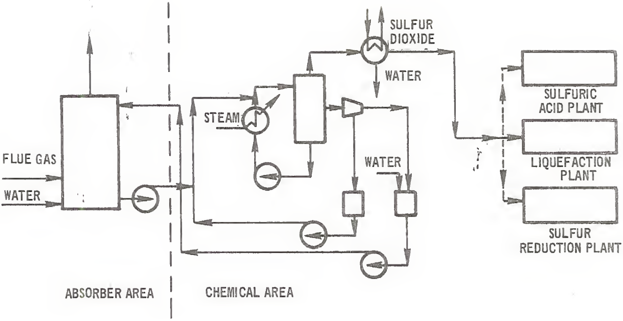


Figure 4-5 Davy Power Gas scrubbing process.

"The liquid phase from the evaporator crystallizer is sent to a centrifugal separator where the crystals of sodium sulfite are removed. These crystals are added to the water that was condensed from the SO_2 stream and the solution thus formed is recycled to the scrubber. The clarified liquor from the centrifugal separator is recirculated to the evaporator. A portion of the clarified liquor is purged from the system in order to prevent a build-up of sodium sulfate in the system. The amount of sodium sulfate in the feed to the scrubber is controlled at about 5 percent by weight.

"A partial list of commercial applications of the Davy Power Gas sulfur dioxide absorption system is shown in table 4-5."

Section II E following describes some of the possible secondary pollution problems.

Appraisal of Operating Problems Peculiar to Treatment of Smelter Effluents

"The advantage of the Davy Power Gas scrubbing system is the simplicity of its unit operating and the avoidance of steam stripping of the absorbent, thus substantially reducing steam requirements.

"It is recommended that the process off-gas be as free as possible from dust, fume, and vapor or gaseous contaminants such as arsenic trioxide, hydrogen chloride, hydrogen fluoride and sulfur trioxide. Solid particles in the absorbent solution may produce mechanical problems such as plugging or erosion while acidic gases and vapors will consume absorbent or cause chemical problems such as corrosion.

"Smelter effluents in many cases could also cause problems with the system due to the presence of high concentrations of oxygen in the process off-gas and the possibility of introducing potential oxidation catalysts into the absorbent. In both cases a build-up of an excessive sodium sulfate concentration in the absorbent could result.

"In the required purging of sodium sulfate from the absorption system, a portion of the sulfur dioxide is lost because of purging of associated sodium sulfite and sodium bisulfite. Total sodium sulfate formation directly effects the quantity of make sodium hydrogen required [sic]."

Table 4-5 DAVY POWER GAS INSTALLATIONS (Survey of Operating Experience)

				SO_2 Concentration	
	Company	Process	Volume	Inlet	Outlet
1.	Olin Corporation Paulsboro, New Jersey[2W]	Sulfuric acid plant tail gases	45,000 SCFM	4500 ppm	<500 ppm
2.	Japan Synthetic Rubber, Ichihara City, Chiba, Japan[2W]	Two oil-fired boilers	124,000 SCFM	2100 ppm	<200 ppm
3.	Toa Nenryo Kogyo, Ltd. Kawasaki, Kanagawa, Japan[2W]	Sulfur recovery plant tail gas	41,000 SCFM	13,000 ppm	200 ppm
4.	Standard Oil Company of California, El Segundo, California[5W]	Three sulfur recovery plant tail gases	75,000 ACFM		500 ppm

E. Secondary Pollution by Possible Control Methods

As in Section IID, the information in this section was taken from the EPA document "Background Information-Proposed New Source Performance Standards for Primary Copper, Zinc, and Lead Smelters" (11). Notations as to the sources of materials for this document have been deleted from the quotes.

8.3 Neutralization of Sulfuric Acid

"The degree of SO_2 control attained by a smelter directly indicates the amount of sulfur-containing materials which must be marketed or discarded. Current strong SO_2 gas stream control is utilized on the basis of marketability. In the past, sulfuric acid or liquid SO_2 plants have been constructed and operated to produce sulfuric acid or liquid SO_2 in sufficient quantities for sale or internal consumption. Of the 29 existing domestic primary copper, zinc, and lead smelters, fifteen smelters produce sulfuric acid and one smelter produces liquid SO_2. These two commodities have been the only sulfur-containing materials produced in the United States from smelter off-gases. Future control plans, as envisioned by these existing facilities to ensure compliance to local and national ambient air quality standards, were presented in Section 5. These plans include the construction of additional sulfuric acid and liquid SO_2 plants. One new smelter, the construction of which has just been announced, plans to produce elemental sulfur from smelter off-gases. Thus, in all probability, much of the sulfur which enters a nonferrous smelter as a constituent of the concentrate will be recovered from smelter off-gases through the utilization of an elemental sulfur, a liquid SO_2, or a sulfuric acid plant.

"Table 7-1 tabulates SO_2 recovery statistics for the existing domestic lead, zinc, and copper industries:

Table 7-1. SULFUR OXIDE GENERATION AND RECOVERY
AT U.S. SMELTERS (1969-1972)

Type Smelter	Concentrate Processed (T/D)	Sulfur Content (T/D)	SO_2 Generated (T/D)	SO_2 Controlled (T/D)	Overall SO_2 %Control	Equiv. H_2SO_4 Prod. (T/D)
Copper	18,970	6,070	11,900	3,700	31	5,660
Zinc	3,405	1,022	1,940	1,322	68	2,000
Lead	2,950	525	980	260	27	400

Thus, an approximate total of 8,060 tons per day of sulfuric acid are currently being produced and consumed by either internal usage or the domestic market. Magnitudes of the specific applications of this metallurgically produced sulfuric acid are not known. The primary application of this sulfuric acid is for the production of fertilizer. Some acid is used as a leaching medium for oxide ores. Zinc smelters in the northeast section of the United States supply acid to steel mills for steel pickling. Several smelters utilize their by-product sulfuric acid internally as makeup for electrolytic processes, while other smelters employ large chemical companies which in turn, market the acid.

"Cost data received from several smelters that operate metallurgical sulfuric acid plants indicate that, on the average, the product acid is currently being sold at a net loss. Of the reporting smelters, the zinc and copper facilities indicated a net profit; whereas, the reporting lead smelters stipulated a net loss in acid sales. Since cost data were not received from all metallurgical acid producing facilities, the profit and loss averages computed for the nonferrous industry do not supply a complete picture of sulfuric acid profitability.

"New SO_2 control schemes planned by the domestic copper industry should recover an additional 3000 tons per day of SO_2, as the equivalent of 4600 tons per day of sulfuric acid. All but one of the existing copper smelters which are adding new SO_2 controls have found markets for this additional sulfuric acid. The one smelter which has not yet found a firm market plans to dispose of its abatement-derived sulfuric acid by neutralization. SO_2 abatement plans made by the existing zinc and lead smelters should not increase acid production very much beyond the values shown in Table 7-1.

"Recently performed studies have indicated that an overabundance of sulfur is a virtual certainty for at least another decade and that the input of abatement-derived sulfur into the domestic market will produce marketing difficulties. Another important conclusion drawn from these investigations is that smelters in the southwestern section of the United States are expected to produce an excess of sulfur-containing materials above and beyond that quantity which can be marketed. Thus, the possibility of long distance freight charges and the associated negative profitability may cause abatement-derived, sulfur-containing materials to be discarded.

"For the purposes of this discussion, an assumption is made that all elemental sulfur, which would be produced but not marketed, could be safely stored in block form in the vicinity of the smelter. Shelter could be provided so that fugitive dusting and wash-off would not occur.

"The primary method for disposal of abatement-derived sulfuric acid is by neutralization with limestone. The chemical steps involved in the production and neutralization of smelter sulfuric acid follow:

1. Sulfur enters the metal production scheme principally as a sulfide of zinc, lead, copper, and iron (i.e., ZnS, PbS, Cu_2S, and $CuFeS_2$).

2. Conversion of the input sulfur to sulfur dioxide, which is then contained in the smelter off-gases:

   a. Zinc roasting
      $2ZnS + 3O_2 \rightarrow 2ZnO + 2SO_2$

   b. Lead sintering
      $2PbS + 3O_2 \rightarrow 2PbO + 2SO_2$

   c. Overall copper recovery equations
      $Cu_2S + O_2 \rightarrow 2Cu + SO_2$
      $2CuFeS_2 + 5O_2 \rightarrow 2Cu + 2FeO + 4SO_2$

3. Conversion of the sulfur dioxide contained in the smelter off-gases to sulfuric acid:

   $2SO_2 + O_2 \rightarrow 2SO_3$

   $SO_3 + H_2O \rightarrow H_2SO_4$

4. Neutralization of sulfuric acid with limestone:

   $H_2SO_4 + CaCO_3 \rightarrow CaSO_4 + CO_2 + H_2O$ + Other Salts

On a stoichiometric basis, one mole of limestone would be required to neutralize one mole of sulfuric acid; and, in turn, one mole of $CaSO_4$ would be produced. Besides the chemical production of $CaSO_4$, other salts such as $CaSO_3$ and $MgSO_4$ are formed. The $MgSO_4$, which is formed when $MgCO_3$, generally a minor constituent of limestone, reacts with sulfuric acid (sic).

"Of primary importance in the discussion of secondary pollution is the amount of $CaSO_4/CaSO_3$ and $MgSO_4$ produced for various air pollution control schemes. Since $CaSO_4/CaSO_3$ would be produced in large volumes as a sludge, its disposal, if not marketed, could produce solid waste problems. If gypsum ponds were employed as disposal sites for the $CaSO_4/CaSO_3$, fugitive dusting of the dried residue could occur at some later date. As with the phosphoric acid gypsum ponds in Florida, the aesthetic values of the area surrounding the gypsum piles are generally impaired. The degree of solubilization of magnesium could also provide the basis for secondary water pollution. Magnesium salts have a laxative effect at high concentrations, particularly upon new users, although a tolerance to magnesium can be developed by the human body over a period of time. The American Smelting and Refining Company, after performing a laboratory-scale limestone neutralization study, stated that even with a low percentage conversion of magnesium to the soluble sulfate (salt) form, a tremendous amount of soluble material would be put out on a dump subject to rainfall.

"This same study attempted to define the neutralization technique, as well as the fineness of the limestone grind, which should be employed for optimal results. Two types of limestone were used, one taken from the Hayden, Arizona area and the second from Montana.

> These two limestones represented, respectively, the low and high content values of magnesium, reported as 0.9% and 3.3% MgO. Two different neutralizing techniques were employed, a wet method and a dry method. With both techniques, the fineness of the limestone grind was determined to be the major parameter for providing the potential magnitude of secondary pollution. It was determined that the finer the grind, the smaller the amount of limestone required for neutralization, but the greater the solubilization of total magnesium. Magnesium solubilization was found to vary from approximately 40 to 80 percent of the total magnesium, depending upon the grind of limestone used for neutralization. On an absolute scale, the greater the weight of limestone required for the coarser grind produced a greater magnitude of solubilized magnesium. Based upon this laboratory investigation, an optimal grind produced a limestone requirement of 129 percent of stoichiometric. The final grind value, which would be used in actual practice, could only be determined by means of both an economic and a pilot-plant study."

The following example illustrates quantities of potential solid and liquid wastes that might be produced by acid neutralization by the wet process at the Anaconda smelter (11):

The Anaconda smelter will include a fluo-solids roaster, electric furnaces, and converters in 1975 according to the company. The copper concentrate, containing 31.4% sulfur, will be processed at rates up to 1940 T/day. In order to achieve 90% control about 86% of the input sulfur will require conversion to sulfuric acid, the other 4% being retained in slag, waste sulfuric acid from the scrubber and flue dust. Sulfur dioxide emissions from the roaster, furnaces, and converters will be controlled by the 990 T/day double absorption sulfuric acid plant and a new sulfuric acid plant producing 620 T/day. If 250 T/day are used at the Butte mines, and 90 T/day are sold, then about 1270 tons per day will remain to be neutralized. If the acid is neutralized with a 150% stochiometric quantity of limestone containing 48.2% calcium oxide and 3.3% magnesium oxide, about 2,240 T/day of limestone would be required and 2,520 T/day of waste material would be produced. As a comparison, the concentrator at Anaconda now produces 1,225 T/day of waste, and the smelting process produces up to 1,300 T/day of slag. Therefore, under the above conditions, the amount of waste material leaving the smelter would increase by about 100%. The volume of 2,520 T/day of waste neutralization material would be 1,290 yds^3/day.

Neutralization, in reality, probably would not produce the high magnitude of potential solid and liquid pollution indicated by the above example.

> "Limestone requirements of less than 150 percent stoichiometric may be realized for some neutralization programs. The value of 3.3 percent MgO used in the above illustrations is high when compared to other limestones, such as that found in Hayden, Arizona. The form that the magnesium could take in the neutralization product is also questionable. Solubilization does occur to some extent, as indicated by the American Smelting and Refining Company's investigation. Formations of sulfites and oxides of magnesium, as well as unreacted $MgCO_3$, are possible.
>
> "Regarding secondary pollution from the neutralization of sulfuric acid by the "wet" process, large quantities of solid by-products will be formed and will, in most likelihood, cause aesthetic pollution and future fugitive dusting pollution. The potential for future consumption of these by-products in the manufacture of gypsum wallboard, as well as other gypsum materials, is very possible. The formation of the soluble forms of magnesium will present an environmental problem. Degrading of water quality will not occur if a closed-loop operation is employed. If used, the degree of open loop would be dependent upon the characteristics of the process wastes, the quantity of the waste discharge, and the magnitude of the receiving stream. The disposal area would have to be designed so that ground water seepage of supernatant runoff would be prevented. Precipitation of soluble magnesium salts contained in the settling pond could be accomplished. The addition of lime to a purge stream taken from the settling pond could maintain the pond's concentration of soluble magnesium salts at a constant level. The magnesium salts contained in this purge would be converted to insoluble magnesium hydroxide which would later settle to the bottom of the pond.
>
> "To indicate the solid waste pollution problem associated with metallurgical sulfuric acid neutralization, the following comparison is made. If all of the sulfur contained in the lead, zinc, and copper concentrates, processed during a one-year period, were converted to sulfuric acid and then neutralized with 150 percent stoichiometric limestone, the resulting production of solid waste would be approximately 18 million tons. During 1970, the wet process phosphoric acid industry produced 4.4 million tons of P_2O_5. The resulting production of solid waste gypsum was 22 million tons. The occurrence of the first situation is extremely unlikely, if not impossible.
>
> "With an awareness of the economics of acid neutralization, as well as the possibility of producing secondary pollution, one domestic primary copper smelting company has developed a dry limestone neutralization process. The product of this method, demonstrated by means of a pilot plant study, is a solid. Approximately two to three tons of this solid neutralization product, which is a combination of gypsum and unreacted limestone, are formed for each ton of neutralized sulfuric acid. After

discharge to a disposal area, a hard crust forms over this material; this crust minimizes secondary pollution problems such as dusting and rain water runoff of contained soluble materials. Because of the high content of unreacted limestone found in the solid neutralization product, a market has not yet been found.

"The economics of neutralization of sulfuric acid have been estimated and are contained in Chapter 6 of this report.

"There is no doubt that an analysis of the disposition of sulfuric acid produced from smelter effluents is extremely complex. Some predictions regarding the potential necessity for acid neutralization can be made."

"3. New copper smelters will most likely employ process technology which will allow the production of either elemental sulfur or liquid SO_2. This generalization has already been evidenced by the announced construction of the new Phelps-Dodge copper smelter at Tyrone, NM which will produce elemental sulfur from flash smelter off-gases. The modification of existing copper smelting facilities may necessitate neutralization since smelter operations indicate that their acid markets are already saturated."

8.4.1 Ammonia Scrubbing Systems

"This media chemically absorbs the SO_2 and the reaction products (sulfites, bisulfites, and sulfates of ammonia) are discharged as a solution at the scrubber outlet. If this salt solution were released directly to a ground water supply without prior oxidation, a chemical oxygen deman (C.O.D.) could produce an anerobic effect on the water course. Even if the ammonium solution were completely oxidized to ammonium sulfate prior to release, the ammonium ion has the potential of extracting oxygen from the water course. Since these ammonium salts are soluble, their addition to a water course would also increase the total dissolved solids of that course. Thus, it is extremely important from the standpoint of secondary pollution that numerous options exist for the conversion to other final scrubber products.

"One proven technique involves acidifying the ammonia sulfite-bisulfite scrubber solution with concentrated sulfuric acid. Two products will be formed, a strong SO_2 gas stream and ammonium sulfate. The governing chemical equations are:

$$2NH_4HSO_3 + H_2SO_4 \rightarrow (NH_4)_2\ SO_4 + 2SO_2 + 2H_2O$$

$$(NH_4)_2\ SO_3 + H_2SO_4 \rightarrow (NH_4)_2\ SO_4 + SO_2 + H_2O$$

"The SO_2 can be used for the production of sulfuric acid, liquid SO_2, or elemental sulfur. In some sections of the U.S., ammonium sulfate is a saleable fertilizer. If a limited market exists for ammonium sulfate, other ammounium salts can be produced by employing other concentrated acids in lieu of H_2SO_4. Namely, ammonium nitrate or ammonium phosphate can be produced by using nitric or phosphoric acid, respectively. Thus, if a fertilizer market does exist and the required type of acid is available in consumptive quantities necessary for the salt production, secondary pollution from this type of operation will be minimal."

"Other techniques have been studied and have even been applied in production which either produce ammonia for recycle or allow materials to be made for marketing. Ammonium bisulfite has been found to be an effective copper leaching reagent, since it reduces the cost of metallic iron used as the precipitant. Finally, the double alkali scheme, which would produce calcium sulfate as the solid waste material and ammonium hydroxide as the return solution to the ammonia scrubber, may soon be available for SO_2 control.

"In summation, the salt solution produced by the ammonia scrubbing technique could produce secondary pollution, if it were not for the numerous methods available for the production of saleable by-products or safe disposal methods."

8.4.2 Sodium Sulfite-Bisulfite Scrubbing

"This system has not yet been applied to the off-gases of a primary lead, zinc, or copper smelter.

"The scrubber medium for the system is a soidum sulfite-bisulfite-water solution. The SO_2 contained in the gas stream being scrubbed chemically reacts with this solution, and the final scrubbing solution is a sodium sulfite-bisulfite-sulfate-water mixture. Since the sodium sulfate contained in this mixture can not chemically aid the scrubbing process, the sulfate content must be held constant if the scrubber effluent is to be recirculated; thus, the need for a purge stream. Generally, the sodium scrubber purge stream contains 4.5 to 5.5 percent sodium sulfate. The magnitude of this stream is directly dependent upon the amount of oxygen contained in the scrubbed off-gas, since this oxygen will drive more sulfite and bisulfite to sulfate. If this purge stream were discharged directly to a water course, possible water pollution, in the forms of chemical oxygen demand and dissolved solids, could occur.

"One method which can be used to partially reduce the potential water pollution problems derived from the direct discharge of the sodium-based scrubber purge is to convert most of the effluent's sodium sulfite content to sodium sulfate. This conversion is possible by the addition of sulfuric acid, or in chemical form:

$$Na_2SO_3 + H_2SO_4 \rightarrow Na_2SO_4 + H_2O + SO_2$$

$$2NaHSO_3 + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O + 2SO_2$$

Most of the SO_2 will emerge as a strong SO_2 gas stream. The resulting solution, containing dissolved sodium sulfate and a very small amount of sodium sulfite, will have a pH of about 1 or 2. After caustic is added and the pH is raised to about 7, the final solution can be discharged to a water course if the quantity of discharge does not present a dissolved solids water pollution problem. Two domestic regenerative sulfuric acid facilities are using this method. Prior to scrubbing, the gas streams at both facilities contain about 4500 ppm SO_2, 8 percent oxygen, and have gas volumes of nearly 70,000 scfm. Each final discharge stream contains approximately 20,000 pounds per day sodium sulfate (reported as sulfate) and 100 pounds per day sodium sulfite (reported as sulfite). The equivalent effluent flow rate from each site is nearly 8 gallons per minute, part of which is water dilution which ensures the retention of sodium sulfate in solution while processing.

"In some instances of SO_2 control by the usage of sodium-based scrubbing systems, the discharge of the scrubber purge to a water course, even after acidification, could produce dissolved solids water pollution. Various techniques to remedy this potential pollution problem are currently being formulated and evaluated by vendors and current, as well as potential, users of this scrubbing system. The sodium-based double-alkali scrubbing process is one of these techniques. This technique involves the removal of SO_2 from a process off-gas by means of the sodium scrubbing method. The purge solution, composed of sulfites, bisulfites, and sulfates of sodium, is then treated with lime or limestone to remove, as a precipitate, solid calcium sulfites and sulfates and to regenerate sodium hydroxide and sodium sulfite in solution. Thus, an essentially insoluble solid product will be formed and can be disposed of as a solid waste, and a liquid effluent can be returned to the scrubber for reuse. No secondary water pollution problems should occur."

"One application of a sodium-based scrubbing system is currently under construction at a mid-west United States electrical power generation site. The inlet gas stream to the scrubber contains 2200 ppm SO_2 and has a volumetric flow rate of about 300,000 scfm. Approximately 150 gallons/minute of recycled stream will be removed from the sodium absorber and will be sent to an evaporator. Within this evaporator, steam will strip the solution, and a SO_2 effluent with an approximate 85 percent strength will be liberated. This strong SO_2 gas stream will be used for the production of elemental sulfur. A purge stream of about 15 gallons/minute will be removed from the evaporator and then sent to a crystallizer unit. Chilling of the purge stream in the crystallizer unit will cause the contained sodium sulfate to selectively crystallize. The remainder of the purge stream, which will principally contain sodium sulfite, will be recycled to the evaporator. The final crystallized salt will contain 70 percent sodium sulfate, 11 percent sodium thiosulfate, and the remainder as sodium sulfite. This crystallized salt will then be sent to a conventional pulp mill, where it will be used as a chemical make-up."

8.4.3 Dimethylaniline (DMA) Scrubbing

"The dimethylaniline scrubbing technique has been successfully applied to a portion of the sinter machine off-gases of a domestic lead smelter (no longer operating) and a segment of the process gas streams of a domestic copper-pyrite operation. The DMA system will shortly be used to concentrate the SO_2 contained in the converter effluent at one domestic copper smelter and a combination of the reverberatory furnace and converter effluents at a second copper smelter."

"The resulting purge stream contains mostly dissolved solids, in the form of sulfates and sulfites of sodium, and trace amounts of DMA. The volume of this solution and its sodium salt content are principally dependent upon DMA plant capacity, the DMA scrubbing tower operating temperature, and the SO_2 content of the treated gas stream. The pH of the waste stream is maintained between 5 and 6. If the pH were to fall below 5, a larger amount of DMA would be lost to the purge stream; whereas, if the pH were to rise on the basic side of 6, the effluent would contain a greater amount of sodium sulfite. The pH of the system can easily be maintained between five and six.

"To illustrate the approximate magnitude of waste effluent which the DMA process could produce, assume that the absorption (scrubbing) tower operating temperature is 30°C. If the gas stream being scrubbed contains 5 percent SO_2, by volume, approximately 40 pounds of Na_2SO_4 is formed in solution per ton of SO_2 recovered. If the SO_2 concentration were 0.5 percent, with all other factors being equal, approximately 400 pounds of Na_2SO_4 would be formed in solution for each recovered ton of SO_2.

"This effluent is not recycled. If it were discharged directly to a water course without prior treatment, the possibilities of water pollution by means of COD and dissolved solids could exist. Because DMA is an organic compound, it is assumed that the DMA in high concentrations could also produce water pollution."

"One existing smelter which utilizes two DMA units to produce liquid SO_2 will shortly initiate the construction of a water purification system which will be a form of double alkali. The purge stream from the two DMA units has a flow rate varying from 20 to 25 gallons/minute. This effluent has the following average analysis:

25 ppm DMA
45,000 ppm dissolved solids (principally as sulfates and sulfites of sodium)
18 ppm suspended solids
5.8 pH

The purge will first pass through an activated carbon filter to remove DMA, and the outlet concentration of DMA after filtering will be less than 5 ppm. The solution will then join other plant effluents, all of which will then be neutralized with lime. Calcium sulfate and sulfite will precipitate out and the solid will be sent to an impoundment area, from which the final effluent will be discharged to a local river. The company anticipates that the spent activated carbon can be safely land-filled in enclosed containers.

"An existing domestic primary copper smelter is currently constructing a DMA unit, which will concentrate the SO_2 contained in a portion of the smelter's converter effluent. The waste by-product effluent from the DMA unit is planned to be used for cooling of converter gases in a balloon flue (this should reduce SO_3 formation) and as a gas stream conditioner prior to electrostatic precipitation. It is anticipated that most of the waste solution will become a component of the electrostatic precipitator dust, which will be shipped to a lead smelter for further processing.

"A DMA unit is currently being "lined-out" at another domestic primary copper smelter. This smelter is integrated in that it produces both copper concentrate and blister copper on-site. The purge stream from the DMA unit will vary between 30 and 50 gallons per minute, depending on the gas stream being treated by the unit. The pH of the purge stream will be maintained between 5 and 6 and, under normal operating conditions, will contain approximately 0.15 ml DMA/1. of purge (150 ppm DMA, by volume). This effluent will combine with nearly 4500 gallons per minute of tailings flow from the copper concentrating operation. the entire flow will then proceed to the tailings pond area. Water in these ponds is recirculated back to the concentrating department, thus providing a closed loop effluent operation. During a one- to two-day period of each month, the concentrator will not operate, and the DMA purge effluent will proceed to a special waste pond. No recirculation will occur from this pond. The concentration of DMA contained in the purge stream will be visually controlled by the DMA plant operator (With low concentrations of DMA, the effluent is colorless; whereas, if the DMA content is excessive, the effluent color becomes purple.). The company states that no secondary pollution from this purge stream is anticipated.

"In summation, the DMA purge stream contains mostly sodium sulfate and sulfite with trace quantities of DMA. If this effluent were released directly to a water course, the possibility of water pollution by means of COD, dissolved solids, or DMA content could exist. Since, as shown by the text of this section, various means for minimizing secondary pollution exists, or have adequately demonstrated potential, DMA should not provide a secondary means for contamination of the environment."

8.4.4 Calcium-Based Scrubbing Systems

"This type of SO_2 control device has not been directly applied to effluents of the primary domestic lead, zinc, and copper industries.

"Basically, a gas stream containing SO_2 is scrubbed with a lime or a limestone slurry; the clean gases are released to the atmosphere while the SO_2 ladden slurry is split with one portion flowing to a pump tank and the other portion going to a settler. This settler, in most situations, would be a settling pond. Ideally, calcium sulfite and calcium sulfate are precipitated out in the settler as a solid by-product which can be disposed of easily and the liquid effluents from both the pump tank and the settler are recirculated back to the scrubber.

"As was discussed in 4.3.1, scaling may produce operation problems within the system. One method currently used to reduce the amount of scaling is to discharge to a local water course a portion of the liquid effluent from the scrubber. Water pollution derived by this discharge is possible. This liquid discharge would invariably contain calcium and magnesium as unreacted carbonates, various sulfates and chlorides of calcium and magnesium, and possibly dissolved salts of trace metals which were contained in the scrubbed gas stream. Thus, in discharging this effluent directly to a water course, the possibility of water pollution by means of dissolved solids, chemical oxygen demand, and increased hardness of water can exist. Other pollution produced by the release of soluble magnesium salts, as well as salts of various trace metals, is possible. If this eflfuent discharge were to produce water pollution, water purification methods would have to be utilized prior to the discharge.

"Calcium-based systems of the future will be designed in such a fashion that closed loop operation can be practiced. With this type of operation, the possibility of water pollution by means of the direct discharge of the scrubber effluent to a local water course will be minimal. For this analysis, it will be assumed that the calcium-based scrubber has been designated to compensate for the problems derived from scaling. Since there will be no discharge to local waters and since the liquid effluent will be in a closed circuit within the scrubbing system, one would expect the various concentration of materials contained in the scrubber slurry to build up with time. Secondary pollution which would be produced by such a system would now be that of solid waste: the disposal of the calcium sulfate and calcium sulfite sludge. This sludge material will contain a large amount of water, the relative magnitude of which would almost solely depend upon economics. Pilot plant studies of calcium-based systems have thus far indicated that this sludge, after dewatering, has the consistency of "toothpaste". Final disposal of the material with such a consistency is difficult. The underlying problem which causes the retention of large amounts of water by the calcium-sulfate-sulfite material is its crystalline structure. Initial investigations for determination of the optimum crystal structure of minimal water retention has indicated that large crystals of calcium sulfate are desirable.

"Assuming that the calcium-based systems which may be used in the future on primary metallurgical gas streams for sulfur dioxide control will have closed loop effluents, the potential of water pollution by means of direct discharge of the effluent will be minimal. Ponding capacity and structure will have to be designed in order to insure minimum water pollution potential by means of seepage and runoff. Optimal crystalline structure will have to be determined to insure that the calcium sulfate-sulfite sludge formed by this scrubber can be easily and economically dewatered; thus, allowing the final disposal or commerical usage of this solid by-product."

F. Control Costs

Appendix D contains part of Reference 11 which discusses economics of air pollution control in the copper industry.

New Source Performance Standards, authorized under Section III of the Federal Clean Air Act of 1970 means "a standard for emissions of air pollutants which reflects the degree of emission limitation achievable through the application of the best system of emission reduction which (taking into account the cost of achieving such reduction) the Administrator determines has been adequately demonstrated."

The capital costs in the EPA document were developed for "new town-site smelters." Table 6-11 of Reference 11 shows the capital cost of $8.84 million for a 660 ton per day dual stage acid plant (80,000 SCFM gas flow). This cost does not include auxiliary facilities such as power lines necessary to make an operable unit. It does include neutralization requirements and assumes the availability of unlimited free limestone. In its June, 1973, application for authority to construct, The Anaconda Company reported costs of about $11 million for modifications to the smelter which included the 660 ton per day sulfuric acid plant, water cooled converter hoods, converter uptakes and flues, gas scrubber, glass fiber flue to acid plant, acid storage facilities, and loadout facilities. Therefore, it appears that the EPA cost estimates are also reasonable for constructing new acid plants for existing facilities.

A 950 T./day dual stage acid plant, which has about 4% less capacity than the plant Anaconda reportedly will have in the near future, has the following costs according to Table 6-12, Case 1B, Reference 11. Capital costs of a plant this size would be about $11.4 million. The associated neutralization facility would add $5.5 million. The total annual costs. including neutralization from Table 6-12 would be $5.2 million per year. Operating costs would be

$1.61 million per year. The above cost figures were taken from the electric smelting configuration since the current green feed reverberatory smelting configuration at Anaconda appears to be only temporary.

An 870 T./day dual stage acid plant, in addition to the 990 T./day possible from the existing plant would provide adequate capacity for 90% control of the smelter emissions at rated production. According to Table 6-11, Reference 11, the capital cost of such a plant would be about $8.23 million. Operating costs would be less than $1.61 million per year. Possibly an expansion of the neutralization facility associated with the 990 T./day plant would be required but the cost of this change cannot be estimated with any accuracy. An expansion might not be necessary if markets could be found for the sulfuric acid.

The three older sulfuric acid plants previously associated with zinc roasting (see Section II C and II D above) possibly could be reactivated in the future, thus reducing capital expenditures for acid making capacity.

The operating cost information also contained in Appendix D, based on a model smelter including a 950 T/day dual stage acid plant is summarized below. This model smelter gives estimated costs on the high side since it is based on a size representative of the smallest viable operation and does not consider "economics-of-scale" associated with building larger control units.

The costs for control of sulfur oxides from an electric furnace-converter type smelter are about 3.03 or 1.87 cents/lb of copper produced with or without total neutralization of the sulfuric acid produced. Assumptions include a smelter feed containing 27% copper, 28% iron, and 32% sulfur, total capture by exhaust hoods, no fugitive emissions, no control unit down time, and unlimited free limestone for neutralization. Capital related charges are based on assumptions of depreciation over 15 years (neutralization facility

25 years), interest, insurance and taxes at 10% of total invested capital, and maintenance costs of 6% of capital.

An overall SO_2 control of 99.5% would result if all operating assumptions could be met. In reality, this efficiency will never be achieved because of down time, fugitive emissions and other minor problems. Use of a single stage acid plant would require slightly lower costs of 2.79 ¢/lb.copper with neutralization or 1.68 ¢/lb. without neutralization. Overall SO_2 control theoretically would be about 97.5%.

III. EXISTING AMBIENT ENVIRONMENT

A. Air Quality

A comprehensive study of air pollution in the Deer Lodge Valley was conducted from August, 1965, though June, 1966 (17). This study was conducted by the Montana State Department of Health with partial support from the U.S. Department of Health, Education and Welfare. Sampling included some 400 high volume particulate samples and sixty sulfur dioxide samples using the lead peroxide candle method. This report states: "Levels of sulfur dioxide were excessive in the Anaconda area but dropped off rapidly in all directions from Anaconda."

The geography of the Deer Lodge Valley, with the town of Anaconda at the south end, is quite conducive to meteorological inversions. The valley is about 35 miles long, about 10 miles wide and surrounded on all four sides by high mountains. The elevation at the south end of the valley is about 5,000 feet and is about 4,500 feet at the north end (17).

Surface winds as recorded by the state in valley floor locations near Anaconda are predominantly westerly through southerly with predominant speed range of 3.5 to 30 mph. Winds at stack height are mainly from the southwest in fall and winter periods. Spring and summer seasons bring prevailing winds along the southwest-northeast axis with noticeable components from all other directions. Wind speeds up to 100 miles per hour have been recorded at stack height.

Inversions occur approximately 40% of the time as an annual average. Winter inversions account for about 45-50% of the annual frequency with the spring percentage being about 30. These frequencies are among the highest in the nation. Because of geographic and weather factors, the Deer Lodge Valley has a high potential for air pollution problems (17).

Sulfur dioxide concentrations in the air at or near Anaconda showed a 30% increase between 1961-1962 and 1965-1966. Smelter production between these two test periods increased from 133,227 tons per year to 155,796 T/yr (14). The annual 1971, 1972 and 1973 production figures are respectively 132,793*, 177,725 and 177,503 T/yr (18). Lead peroxide candle tests conducted in 1965-1966 showed that Anaconda has a higher sulfur dioxide concentration than the other stations sampled, Deer Lodge, Galen, Opportunity and Crackerville. The average results were:

Anaconda - 0.74 mg/SO_3/100 cm^2/day
Opportunity - 0.52 mg/SO_3/100 cm^2/day
Galen - 0.39 mg/SO_3/100 cm^2/day
Crackerville - 0.25 mg/SO_3/100 cm^2/day
Deer Lodge - 0.17 mg/SO_3/100 cm^2/day

Maximum results were:

Anaconda - 0.99 mg/SO_3/100 cm^2/day
Opportunity - 0.85 mg/SO_3/100 cm^2/day
Galen - 0.60 mg/SO_3/100 cm^2/day
Crackerville - 0.32 mg/SO_3/100 cm^2/day
Deer Lodge - 0.29 mg/SO_3/100 cm^2/day

The units given above are milligrams of sulfur trioxide formed per day in the candles with surface areas of 100 square centimeters.

Sulfation rate data from state ambient air sampling in 1971, 1972 and 1973 are summarized in Table 2. The sampling locations are shown in Figure 3. Several facts are evident. Both the maximum monthly and annual averages were exceeded in 1971, 1972 and 1973. For some of the stations a trend over these three years was evident, recorded concentrations were less in 1973. This drop corresponds in time to the installation of the water cooled hoods on the converters and use of the 660 T/day sulfuric acid plant. First use of the new ducting began about January, 1973 and the sulfuric acid plant was started in June, 1973. Even though the acid plant was not started until June, 1973, the use of the new hoods and ducting eliminated almost all of the low level sulfur oxide emissions from the openings in the converter building. Approximately 95% emission control is possible using the new hoods.

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*July, August and part of September 1971 were involved in a strike.

Table 3 and figure 4 summarize sulfation rate data from Anaconda Company sampling sites for 1971 through 1973. Values here also show a slight decrease from 1971 and 1972 to 1973.

Sulfur dioxide sampling data for the Anaconda, Montana area from December, 1971 to November, 1973 are summarized in Table 4. Sampling locations are shown in Figure 5. It can be seen that violations of the Montana 1-hour and national primary and secondary standards occurred in 1971, 1972 and 1973 although the concentrations of sulfur dioxide appear to be less in 1973. Only the Poor Farm station has enough data for any kind of comparison of the violations in the three years. The major problem with most ambient sampling in the smelter area lies with the large difference between the elevation of the top of the stack and the valley floor where most sampling has been done. Most of the acceptable sampling sites at higher elevations around the smelter, where higher ground level concentrations of sulfur oxides are expected, have, until very recently, been inaccessable to the air sampling equipment.

Suspended particulate data, obtained with glass fiber high-volume filters is summarized in Table 5. To date the Anaconda Company has refused to submit any suspended particulate data from their sampling stations. A discussion of suspended particulate levels follows in the health effects section.

Data handling for state, Environmental Protection Agency and Anaconda Company was done by Air Quality Bureau personnel.

TABLE 2

State Air Quality Bureau Sulfation Data
Number of Violations of State Ambient Air Quality Standards

	1971		1972		1973	
Stations	0.50* Monthly Standard	0.25# Annual Standard	0.50 Monthly Standard	0.25 Annual Standard	0.50 Monthly Standard	0.25 Annual Standard
Main Gate	6(.94)+	1(.63)				
East Anaconda Jct.	7(4.30)	1(2.26)	4(4.80)	1(1.73)	4(1.10)	1(.52)
Lost Creek 1 Mile	5(.74)			1(.42)		
Sky Lodge Airport	8(1.90)	1(1.02)	4(2.30)	1(.87)	4(.65)	1(.38)
Johnson Ranch	3(.80)	1(.43)	2(.66)	1(.41)		
Poor Farm				1(.57)	3(1.03)	1(.46)
Antelope Creek					1(.65)	1(.32)
Mill Creek RR	6(2.90)	1(1.43)	6(2.70)	1(1.09)	2(.69)	1(.26)
Country Club Rd	7(1.20)	1(.61)	5(1.20)	1(.62)		
Crackerville	6(1.30)	1(.73)				
One Way Sign Oppor.	2(.68)	1(.61)	1(.77)	1(36.)		
Durant Canyon			1(.53)	1(.42)	3(.59)	1(.34)
Vortex					2(.65)	1(.30)
Willow Glen					3(.75)	1(.40)
Mill Cr. 1.2 miles	4(.86)	1(.37)				
Mill Cr. 10 Miles	4(.87)	1(.38)				1(.27)
Post Office						1(.29)
Church of Christ	6(.92)	1(.54)				
Race Track Exit	7(1.10)	1(.64)				
Warm Springs	2(.70)	1(.33)				

*0.50 milligrams sulfur trioxide per 100 square centimeters per day, maximum for any one-month period.

#0.25 milligrams sulfur trioxide per 100 square centimeters per day, maximum annual average

+Numbers in parentheses indicate highest value recorded in same units as above

Figure 3 Location of State Air Quality Bureau Sulfation Plates and Hi-Volume Samplers in the Anaconda Vicinity

Sulfation Plates

1	Race Track
2	Antelope
3	Poor Farm
4	Lost Creek
5	Johnson
6	Warm Springs
7	Airport
8	Tailing
9	Jct.
10	C. Club
11	Opportunity
12	Crackerville
13	Durant Canyon
14	Vortec
15	Willow Glen
16	R.R.
17	Mill Creek
18	Main Gate
19	P.O.
20	Church
21	Mill Creek (10 mile)

High Volume Samplers

A	Jr. HIgh Hi-Vol
B	Kirkeby Hi-Vol
C	Johnson's Hi-Vol
D	Bailey Hi-Vol

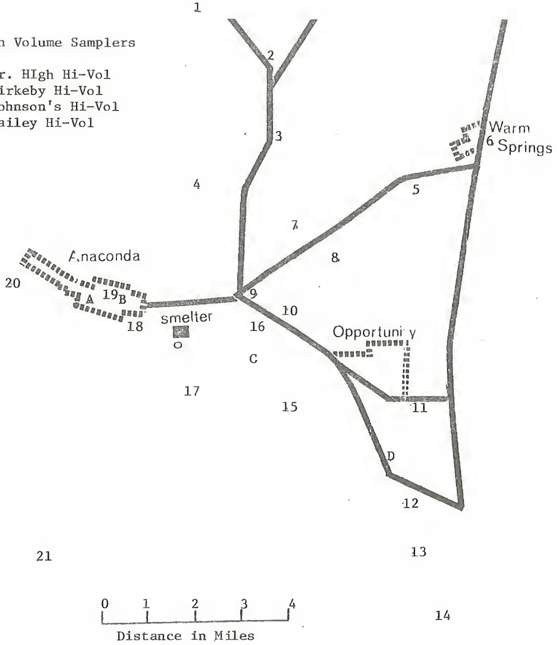


TABLE 3

Anaconda Company Sulfation Data
Average Sulfation Rate Values for the Years Given

Station	1971# (Sep-Dec)	1972# (Jan-Dec)	1973# (Jan-Dec)
#1 Hotel	.248 (.38)+	.343 (.83)	.159 (.30)
#3 Opportunity	.634 (.39)	.501 (.91)	.284 (.51)
#5 Johnson Ranch	.178 (.34)	.289 (.60)	.257 (1.06)
#6 Warm Springs Rd.	.488 (.68)	.647 (1.31)	.395 (1.08)
#9 Warm Springs Crk.	.618 (.79)	.449 (1.44)	.406 (1.67)
#10 Willow Creek	.332 (.62)	.812 (2.52)	.388 (1.11)
#13	-	1.08 (7.00)	.408 (2.88)
#14	-	.992 (1.93)	.436 (1.51)
#15 Airport	-	.384 (.65)*	.431 (1.56)
#18 Poor Farm	-	.513 (3.14)*	.325 (.84)
#20 NE Poor Farm	-	.326 (.83)*	.368 (1.28)
#21 "C" Hill	-	1.074 (9.35)*	.401 (1.22)
#30 Church of Christ	-	-	.324 (.59)
#32 Bailey's	-	-	.301 (.81)
#41 ½ mi. S of Willow Glen	-	-	.452 (.96)
#43 N of Trap Club	-	-	.375 (2.08)
#45 Johnson Ranch	-	-	.261 (.60)
#46 Jones Cattle Co.	-	-	.303 (1.15)
#47 Dutchman S of Meyer Ranch	-	-	.555 (1.86)
#48 Antelope Gulch	-	-	.335 (.97)
#53 Airport	-	-	.466 (1.76)
#54 Mill Creek	-	-	.386 (1.28)

#Values in milligrams sulfur trioxide per 100 square centimeters per day (state ambient air quality standard = 0.25 annual average)
*Less than 3/4 of year available
+Numbers in parentheses indicate highest value recorded in period sampled

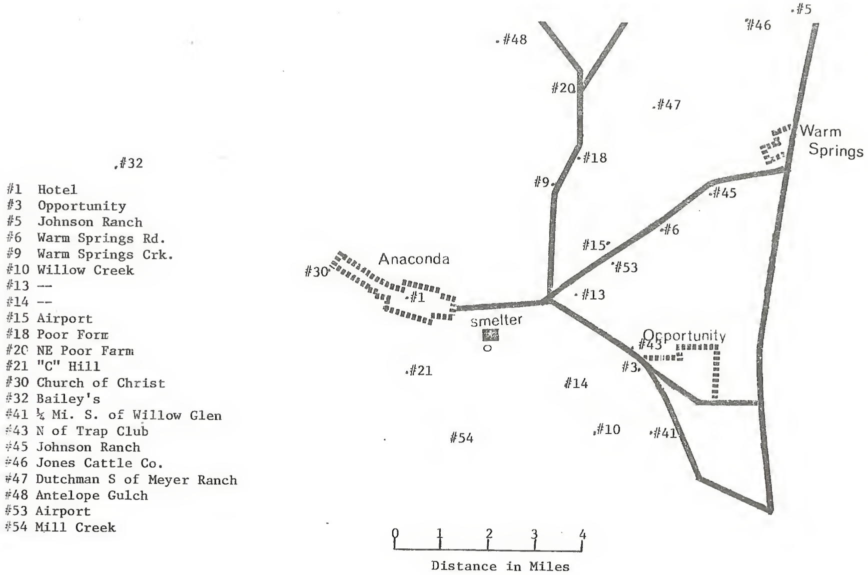


Figure 4. Location of The Anaconda Company Sulfation Plates in the Anaconda Area

#1	Hotel
#3	Opportunity
#5	Johnson Ranch
#6	Warm Springs Rd.
#9	Warm Springs Crk.
#10	Willow Creek
#13	--
#14	--
#15	Airport
#18	Poor Form
#20	NE Poor Farm
#21	"C" Hill
#30	Church of Christ
#32	Bailey's
#41	¼ Mi. S. of Willow Glen
#43	N of Trap Club
#45	Johnson Ranch
#46	Jones Cattle Co.
#47	Dutchman S of Meyer Ranch
#48	Antelope Gulch
#53	Airport
#54	Mill Creek

TABLE 4

Number of Violations of Ambient Air Quality Standards, Coulometric Sulfur Dioxide Sampling

Location, Source and Standard					
Mill Creek (AC)	8/72	9/72-11/72	12/72-2/73	3/73-5/73	6/73-8/73
1 hr^b	0	2(.56)^a	48(.87)	40(.76)	32(.82)
3 hr	0	0	4(.64)	0	0
24 hr	0	0	5(.17)	0	1(.14)
Hotel (AC)	8/72	9/72-11/72	12/72-1/73		
1 hr	1(.27)	8(.53)	15(.86)		
3 hr	0	0	1(.63)		
24 hr	0	0	2(.16)		
Post Office (EPA)	2/73	3/73-5/73	6/73-7/73	9/73-11/73	
1 hr	0	18(.90)	24(.55)	51(.48)	
3 hr	0	2(.65)	0	0	
24 hr	0	0	0	4(.29)	
Willow Glen (State)	3/73-5/73	6/73-7/73	9/73-11/73		
1 hr	6(.50)	8(.35)	1(.27)		
3 hr	0	0	0		
24 hr	0	0	0		
Tailings Pond (EPA)	3/73-5/73	6/73-7/73	9/73-11/73		
1 hr	7(.40)	2(.28)	60(.45)		
3 hr	0	0	0		
24 hr	0	0	6(.24)		
Vortec (EPA)	3/73-5/73	6/73-7/73	9/73-11/73		
1 hr	1(.60)	0	51(.75)		
3 hr	0	0	3(.62)		
24 hr	0	0	3(.44)		
Poor Farm (State)	12/71-2/72	3/72-5/72	6/72-8/72	9/72-11/72	12/72-1/73
1 hr^b	33(.70)^a	1(.28)	0	3(.32)	15(.53)
3 hr	0	0	0	0	0
24 hr	1(.35)	0	0	0	1(.17)

TABLE 4 (Cont.)

Location, Source and Standard					
Antelope Creek (St.)	2/73	3/73-5/73	6/73-7/73		
1 hr	0	4(.42)	0		
3 hr	0	0	0		
24 hr	0	0	0		
Airport (AC)	8/72	9/72-11/72	12/72-2/73	3/73-5/73	6/73-8/73
1 hr	0	0	13(.75)	15(.62)	10(.68)
3 hr	0	0	0	0	0
24 hr	0	0	0	0	0
Warm Springs (St.)	12/71-2/72				
1 hr	0				
3 hr	0				
24 hr	0				
Opportunity (AC)	6/72-8/72	9/72-11/72	12/72-1/73	3/73-5/73	6/73-8/73
1 hr	0	0	4(.81)	12(.45)	5(.45)
3 hr	0	0	0	0	0
24 hr	0	0	0	0	0
Opportunity (St)	6/72-8/72	9/72-11/72			
1 hr	0	0			
3 hr	0	0			
24 hr	0	0			
Kucera (State)	9/72-11/72	12/72-2/73	3/73-5/73	6/73-7/73	
1 hr[b]	0	2(.39)[a]	19(.42)	4(.45)	
3 hr	0	0	0	0	
24 hr	0	0	0	0	
Weather Hill (AC)	9/72-11/72	12/72-2/73	3/73-5/73	6/73-8/73	
1 hr	0	13(.60)	4(.53)	6(.38)	
3 hr	0	0	0	0	
24 hr	0	0	0	0	

[a] Values in parenthesis are maximums for the sampling period given

[b] Air Quality Standards for Ambient Sulfur Dioxide

Montana Standard - 1 hr - 0.25 ppm not to be exceeded for more than one hour in any 4 consecutive days

National Standard - 3 hr (sec.) - 0.5 ppm maximum 3 hour conc. not to be exceeded more than once a year

- 24 hr (primary) - 0.14 ppm maximum 24 hour conc. not to be exceeded more than once a year

Figure 5 Continuous Monitoring for SO_2

1	Antelope	(State)
2	Poor Farm	"
3	Warm Springs	"
4	Opportunity	"
5	Bailey	"
6	Willow Glen	"
7	Kucera	"
8	Airport	(Anaconda Smelter)
9	Anaconda Company	"
10	Mill Creek	"
11	Hotel	"
12	Tailings Pond	(EPA)
13	Post Office	"
14	Vortec	"

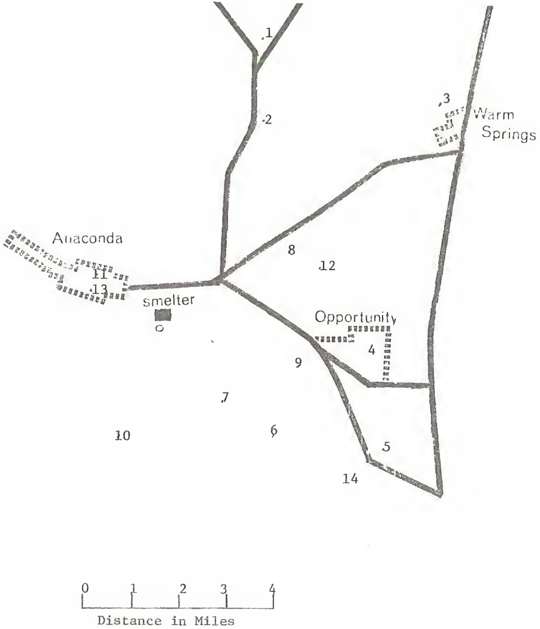


TABLE 5

Total Suspended Particulate Levels in Anaconda Area
Running Year Values
State Air Quality Bureau Data

	Johnson Res. Mill Creek	Kirkeby Res. Anaconda	Jr. High Anaconda	Kucera Res. Anaconda	Bailey Res. SE of Anac.
Geometric Mean (ug/M^3)	49	43	48	20	36
Arithemetic Mean (ug/M^3)	59	46	56	42	44
Max. 24 hour Ave. (ug/M^3)	235	208	249	89	93
No. days over 150 ug/m^3	1	1	3	0	0
No. days over 200 ug/M^3	1	1	1	0	0
No. days data	31	75	119	52	7
Sampling period	3/71-11/71	4/72-11/72	2/71-3/72	12/72-6/73	10/71-11/71

Applicable State Standards

75 ug/M^3 (microgram per cubic meter) annual geometric mean
200 ug/M^3 not to be exceeded more than 1% of days a year

Applicable Federal Standards

75 ug/M^3 annual geometric mean
150 ug/M^3 max. 24 hour conc. not to be exceeded more than once a year (secondary)
200 ug/M^3 max. 24 hour conc. not to be exceeded more than once a year (primary)

B. Vegetation Damage

The Anaconda copper smelter in Anaconda, Montana, is located at the southwestern edge of the Deer Lodge Valley. Elevation in the valley ranges from 5000 - 5400 feet with the lowest levels along the Clark Fork River. The mountains at the edge of the valley reach elevations of 7000 - 9000 feet.

Little timber is found in the valley except along stream and river banks. The valley tree communities occurring along water systems are dominated by willows, aspens, and cottonwoods. With the exception of these riparian communities the valley is devoted to agriculture and residential areas. The higher mountainous regions sustain thick coniferous forests. The forests are comprised mainly of Douglas-fir, Engelmann spruce, Lodgepole pine, Rocky mountain juniper, and Common juniper (19).

Sulfur dioxide (SO_2), which injures vegetation, is produced in the smelting of copper sulfide ores. Although strict emission standards have been set for SO_2, ambient violations still occur during periods of stable meteorological conditions such as inversions.

It is not the SO_2 molecule as such which causes injury to plant tissue. Following absorption into the plant, SO_2 is oxidized to form the sulfite ion SO_3. This ion is extremely toxic to plants and is responsible for visible plant injury, probably because of its reducing property (20). Further oxidation of the sulfite to sulfate by the plant reduces the toxicity by approximately thirty times (21).

Unfortunately several SO_2 sensitive plant species exist in the vicinity of the Anaconda copper smelter. These include Douglas-fir, Limber pine, and Currant (Ribes). The Montana state tree, Ponderosa pine, is particularly sensitive, (22) but is not widely found in its natural habitat near Anaconda. The $SO2$ resistant Junipers which share the same habitat have remained. Though much of the Ponderosa pine land near Anaconda was cut over long ago, reproduction has not occurred.

Some of the agricultural crops grown in Deer Lodge County (Table 7) are susceptible to SO_2 injury. Among these are wheat, alfalfa, barley, and potato (23,24). These are grown for the most part in the northern portion of the valley because the soils in the Anaconda vicinity are not suitable.

Experiments have been conducted on the growth of conifers in soils from the smelter area (25). Heavy metal contamination included excessive quantities of arsenic, copper lead and zinc (Table 8). The concentrations of these metals decreases with soil depth and distance from the smelter but were found to be as much as fifty times the concentrations found in soils from uncontaminated areas. Lodgepole pine grown in these soils showed marked reduction in growth and vigor (Fig. 6). The toxic effect of heavy metals in combination with the fumigation by hazardous SO_2 concentrations substantially increase the vulnerability of plants.

Sulfur dioxide injury is characterized as chronic or acute depending on the length and concentration of the exposure. Chronic symptoms which result from long term exposures at low levels appear as yellowing (or chlorosis) of the affected tissue. Acute SO_2 injury which occurs from short term exposure at higher levels results in areas of dead tissue (necrosis). A plant exposed to both high and low levels of SO_2 may exhibit both chronic and acute damage symptoms. These symptoms usually appear in the marginal and interveinal areas of deciduous leaves, and on the tips of mature conifer needles. With conifers, distinct banding may appear (26). Premature shedding of needles is also typical of SO_2 damage to conifers.

Sulfur dioxide injury has been observed in the Anaconda vicinity (27) (28). The United States Forest Service has reported such injury at 3 out of 8 observation plots (28). Carlson found severe SO_2 injury symptoms on

Limber pine and Douglas-fir five miles north of the smelter. Injury was found also on Currant (Ribes) at another site five miles NNW of the smelter (28). The needles of conifers such as Limber pine in the Anaconda vicinity exhibit characteristic SO_2 injury symptoms of chlorosis and necrotic banding. Injury has also been observed on deciduous trees such as Alder, Cherry, and Poplars. All these symptoms were distinct from those associated with drought, winter kill, or insect and fungal infection as described by Scheffer and Hedgecock (19).

In addition to visible injury the constant onslaught of sulfur and heavy metals has contributed to an abnormally acid soil pH (4.5) and soil erosion (due to the dieback of vegetation). Consequently the trees are subject to windfall which accentuates the erosion problem.

Having appraised these findings, EPA gives examples of levels of SO_2 which are expected to damage vegetation. A sensitivity rank is also included. These findings are presented in Tables 9,5-8 as they pertain to the situation in the Anaconda vicinity.

By comparing these examples of toxic levels with data of the Air Quality Bureau, it becomes immediately clear that levels of SO_2 hazardous to many plants are present in the vicinity of the Anaconda copper smelter (Table 9_A). For example, the SO_2 levels of 0.60-0.65 ppm/2 hours which were monitored at the Anaconda Post Office site on May 11, 1973, would be sufficient to cause visible damage to sensitive plants. SO_2 levels as high as 0.90 ppm have occurred during the period of May 11-14 at this site, increasing the probability of damage to vegetation. (29)

A study of precipitation chemistry of rain water falling within a 40-mile radius around The Anaconda Company Smelter is in progress. An associated study of the short-long needle syndrome of coniferous foliage in the Anaconda, Montana, area is also under way (30).

TABLE 7

List of plants in three susceptibility groups by sensitivity to SO_2 (23)

(Refer to Table 5-8 above)

Sensitive:

Serviceberry (Amelanchier alnifolia Nutt.)

Barley (Hordeum vulgare L.)

Wheat (Titicum aestirum L.)

Alfalfa (Medicago satira L.)

Gooseberry (Ribes sp.)

Intermediate:

Potato (Solanum tuberosum L.)

Douglas-fir (Pseudotsuga taxifolia Brit.)

Fir (Abies sp.)

Lodgepole pine (Pinus contorta Dougl.)

Ponderosa pine (Pinus ponderosa Law)

Western white pine (Pinus monitcola Dougl.)

Poplar (Populus sp.)

TABLE 8

RANGE OF CONCENTRATIONS (IN PPM) OF FOUR HEAVY METALS IN THE SURFACE SOILS NEAR ANACONDA, MONTANA (Taskey 1972)

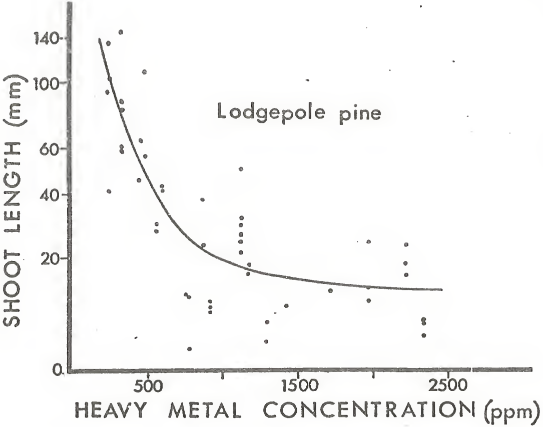
	Total		Available*	
	High	Low	High	Low
Arsenic	2,362	56	258	1
Sample Site	27	44	28	40
Copper	8,450	50	3,260	1
Sample Site	46	41 & 44	46	44
Lead	1,500	23	284	0
Sample Site	27	44	45	44
Zinc	3,100	80	880	0
Sample Site	45	41	30	44

*water soluble arsenic and ammonium acetate extractable copper, lead & zinc.

Levels of Heavy Metals Found in Uncontaminated Soils

Metals	Conc. PPM	Source
Zn	40	(Burkitt, Lester, Nickless)
As	7	(Bishop, Chisholm)
Pb	16	(Goodman, Roberts)

FIGURE 6



Lodgepole pine shoot length as a function of the sum of total concentrations of arsenic, copper, lead, and zinc. (25)

TABLE 9

SO_2 Concentrations Causing Injury to Agricultural and Forest Species (23)

Species	Maximum Average Concentrations							
	1 hr. ug/m^3	ppm	2 hr. ug/m^3	ppm	4 hr. ug/m^3	ppm	8 hr. ug/m^3	ppm
Willow (Salix sp.)	1074	0.41	996	0.38	865	0.33	786	0.30
Trembling aspen (Populus tremuloides)	1100	0.42	1022	0.39	681	0.26	341	0.13
Alder (Alnus sp.)	1205	0.46	1126	0.43	1126	0.43	550	0.21

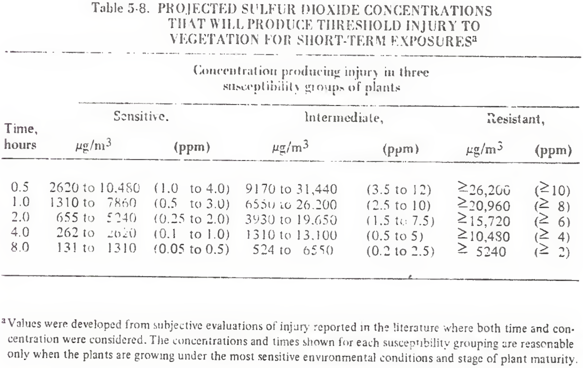


Table 5-8. PROJECTED SULFUR DIOXIDE CONCENTRATIONS THAT WILL PRODUCE THRESHOLD INJURY TO VEGETATION FOR SHORT-TERM EXPOSURES[a]

	Concentration producing injury in three susceptibility groups of plants					
	Sensitive,		Intermediate,		Resistant,	
Time, hours	μg/m^3	(ppm)	μg/m^3	(ppm)	μg/m^3	(ppm)
0.5	2620 to 10,480	(1.0 to 4.0)	9170 to 31,440	(3.5 to 12)	≥26,200	(≥10)
1.0	1310 to 7860	(0.5 to 3.0)	6550 to 26.200	(2.5 to 10)	≥20,960	(≥ 8)
2.0	655 to 5240	(0.25 to 2.0)	3930 to 19.650	(1.5 to 7.5)	≥15,720	(≥ 6)
4.0	262 to 2620	(0.1 to 1.0)	1310 to 13.100	(0.5 to 5)	≥10,480	(≥ 4)
8.0	131 to 1310	(0.05 to 0.5)	524 to 6550	(0.2 to 2.5)	≥ 5240	(≥ 2)

[a] Values were developed from subjective evaluations of injury reported in the literature where both time and concentration were considered. The concentrations and times shown for each susceptibility grouping are reasonable only when the plants are growing under the most sensitive environmental conditions and stage of plant maturity.

TABLE 9A

EPA Coulometric SO_2 Measurements for May, 1973

Anaconda Smelter

Table of Sites where SO_2 levels were sufficiently high enough to cause damage to sensitive plants.

Hourly Reading

Date	Site	SO_2 Range	Time
5/11/73	Post Office	0.60 - 0.65 ppm	10:00 a.m. - 12:00
5/13/73	Post Office	0.30 - 0.90 ppm	10:00 a.m. - 2:00 p.m.
5/14/73	Post Office	0.55 - 0.68 ppm	12:00 - 3:00 p.m.

3 Hour Running Average

Date	Site	SO_2 Peak-3 Hr. Ave.	Time
5/11/73	Post Office	0.48 ppm	10:00 a.m.
5/13/73	Post Office	0.65 ppm	10:00 a.m.
5/14/73	Post Office	0.62 ppm	12:00 noon

C. Human Health

Sulfur dioxide (SO_2) is a well-known atmospheric pollutant and respiratory irritant (35). Inhalation of low concentration quantities may result in the rapid development of laryngeal and bronchial spasm, excessive bronchial secretions and pulmonary edema. In addition, synergistic effects (cooperative action of separate substances such that the total effect is greater than the sum of the effects of the substances acting independently) are widely implicated between sulfur oxides and particulates in causing ill health.

Although much remains to be learned about the heterogeneous reactions between gaseous sulfur dioxide adsorbed on particles, it is presently not possible to discuss sulfur oxides without including particulates in that discussion.

However, since the 1969 issuance of the "Air Quality Criteria for Sulfur Oxides" (NAPCA Publication No. AP-50) re-evaluation of the reactions, although not complete, is in progress. Consider the Senate Congressional Record (36) wherein an evaluation of the present air quality standards is made in summary form.

The Community Health and Environmental Surveillance System study, hereafter "CHESS," in summary, says that there is now more confidence that the current standards for sulfur dioxides and particulates are readily supportable by medical evidence. Adequate support for the position that present air quality standards for sulfur oxides are not too high is now available. In fact, the new sulfate data indicate that the short-term standards may not be low enough to be fully protective.

The CHESS studies made several general conclusions (36):

Long Term

1. Relating to acute respiratory disease, there is a consistent excess of disease in children (ranging from 14 to 64 percent) among those exposed

for three years or longer to SO_2 levels of 90-95 ug/m^3 (0.034 - 0.036 ppm) in the presence of 80-100 micrograms total suspended particulates per cubic meter.

2. Relating to chronic respiratory disease a significant and consistent excess of bronchitis morbidity occurred over an exposure range of 100-350 ug/m3 (0.038 - 0.134 ppm) SO_2 with associate TSP levels of 66 - 365 ug/m^3.

In view of new information on adverse health effects resultant from certain sulfates, suspended sulfate values when added to suspended particulate and sulfur dioxide data effectively lower the threshold levels otherwise linked to degradation of health. For example, the frequency or severity of acute lower respiratory illness in otherwise healthy families would arise under a "worst case"* circumstance where pollutant levels and time durations were as follows:

Duration - 1 year

SO_2 Threshold - 50 ug/m^3 (0.019 ppm)

TSP Threshold - 43 ug/m^3

Suspended Sulfates Threshold - 9 ug/m^3

Short Term (24-hour pollutant threshold levels for adverse health effects as shown)

1. Aggravation of chronic heart and lung disease symptoms in the "well persons."

   SO_2 range 81 - 365 ug/m^3 (0.031 - 0.139 ppm)

   TSP range 68 - above primary standard of 260 ug/m^3

   Suspended sulfates 2 ug/m^3 (Threshold for adverse health effects)

2. Aggravation of cardiorespiratory symptoms in elderly patients with heart disease.

   SO_2 threshold of 84 ug/m^3 (0.032 ppm)

---

*"worst case" estimate attributes an observed adverse health effect to the lowest pollution exposure suggested by the epidemiologic studies after considering only the strongest and most established mathematical analyses.

TSP range 76 - 260 ug/m^3

Suspended sulfates range 3 - 20 ug/m^3

3. Aggravation of chronic lung disease symptoms in elderly patients with chronic lung disease.

   SO_2 threshold 260 ug/m^3 (0.099 ppm)

   TSP range 76 - 260 ug/m^3

   Sulfates range 3 - 18 ug/m^3

4. Aggravation of cardiorespiratory symptoms in elderly patients with combined heart and lung disease.

   SO_2 threshold 180 ug/m^3 (0.069 ppm)

   TSP threshold 46 ug/m^3

   Suspended sulfate range 6 - 17 ug/m^3

5. Aggravation of asthma manifest by higher attack rates

   SO_2 range 23 - 365 ug/m^3 (0.009 - 0.139 ppm)

   TSP range 61 - 260 ug/m^3

   Suspended sulfates - Threshold 0 ug/m^3

It should be pointed out that if suspended sulfate values are included in health effect data, as they were above, that the levels of suspended sulfates necessary to cause adverse health effects were numerically one to two orders of magnitude lower than the levels of sulfur dioxide or total suspended particulates necessary to cause similar effects along.

A. Amdur (37) has shown that the acute effects of sulfur dioxide, considered alone and in response to single short exposures of an hour or less in duration are a readily reversible increase in the flow-resistance of the lungs and airways, which presumably result from bronchoconstriction. In animal studies this construction is shown to be produced by smooth muscle action that constricts the air passages in the lungs. Ib Andersen, et. al, (38) suggested that a nasobronchial reflex bronchoconstriction operates wherein nerve fibers sensitive to sulfur dioxide in the trachea and main bronchi trigger the above mentioned smooth muscle action in humans.

Amdur has shown in guinea pigs that 0.26 ppm sulfur dioxide over a one hour duration is sufficient to cause increased flow-resistance (37).

Another effect of sulfur dioxide is its observed action on nasal mucous flow. A significantly decreased mucous flow rate was documented by Ib Anderson (38) at between 1 and 5 ppm sulfur dioxide. His subjects were all healthy young men without any symptoms or signs of disease in the airways. Not all people are young nor are all healthy; and respiratory diseases are quite common.

In regard to the scrubbing effect of the upper airways upon sulfur dioxide, Amdur (37) agrees that for concentrations greater than 15 ppm, 95% or more is removed in the upper respiratory tract. However, at SO_2 concentrations below 1 ppm, the upper respiratory tract is no longer effective in removing sulfur dioxide. At these concentrations 90-99% of the sulfur dioxide reaches a target organ, the lungs for example.

It is well to note that during resting conditions nasal breathing is generally the rule. At times people are obliged to breathe by mouth; so during exercise the amount of sulfur dioxide, or any small pollutant concentration that reaches the lower airways per unit time is considerably increased. For these reasons, it is likely that children who play a lot out-of-doors are being unduly subjected to the effects of air pollution. Dr. Carl M. Shy (39) et. al., demonstrated a consistent relationship between impaired ventilatory function in children 5 - 13 years of age and exposure to particulates plus sulfur oxide.

In their epidemiology study Drs. Ian T. T. Higgins and Benjamin G. Ferris, Jr. (40) considered studies of children carried out in Britain. The results showed that lower respiratory infections were consistently related to pollution but that upper respiratory infections were not. The threshold levels of smoke (particulates) and sulfur dioxide were respectively 70 ug/m^3 and 90 ug/m^3 (.034 ppm). Both frequency and severity of such infections increased with the amount of pollution. Another study (40) in Holland suggest that environment early in life can produce adverse changes which may persist and contribute to the development of chronic respiratory disease in children.

Dr. R. Frank (41) poses further questions with regard to the interaction of sulfur dioxide with respiratory tract tissues where some of the sulfur dioxide is absorbed. What biochemical or structural responses occur during this transfer? The many respiratory diseases well known to man possibly result from such transfer interactions.

The chemical mechanisms for conversion of atmospheric sulfur dioxide to sulfuric acid and/or sulfate salts are not completely known but probably either or both catalytic and photochemical oxidations occur.

Amdur (37) refers to a study wherein sulfuric acid aerosol of small size produced noticeable respiratory system irriation which was not observed when over ten times the amount of respirable sulfur was given as sulfur dioxide.

A study of the comparative toxicity of sulfates (37) in guinea pigs reveals that zinc ammonium sulfate, zinc sulfate, ammonium sulfate and ferric sulfate all increase airway flow resistance. For submicron sized particles of the above sulfates Amdur noted as much as 20 fold retardation of biological activity in guinea pigs. These studies have shown that the size of irritant particulate materials affects the degree of airway flow resistance. The smaller the particle size the greater is the potency.

Natusch (42) and coworkers in studying emissions from a power plant noted that particulates 0.65 - 1.0 microns in size contained 48.8% sulfur by weight. In general they found that the smaller the particles the greater the percentage of sulfur and or sulfates.

Amdur found that combinations of sulfur dioxide and particles of soluble manganese, vanadium or iron salts promote or catalyze the conversion of sulfur dioxide to sulfuric acid. She found that at high sulfur dioxide concentrations the conversion of sulfur dioxide to its acid form was minimal, whereas at 0.1 - 0.2 ppm sulfur dioxide the metal catalytic conversion to the acid was 10-20%.

Many of the conditions simulated by researchs are present at Anaconda.

1. In 1971 at Anaconda's Junior High School selected pollution levels were as follows:

Date	TSP (ug/m^3)	Suspended Sulfate (ug/m^3)	SO_2 ppm
3/21/71	158	13.0	--
4/19/71	123	19.0	.023*
5/3/71	125	8.8	.03*
5/11/71	113	5.5	.03*

*This data was collected by the Montana State Department of Health. The SO_2 values are one month values collected on sulfation plates using a 0.035 conversion factor from mgSO_3/100 cm^2/day to ppm.

The sulfur dioxide levels are monthly figures and are not directly applicable to daily values. The considerable suspended sulfate levels on the days shown makes the prevalence of higher SO_2 levels probable. As the high volume sampler was on top the Junior High School - some four stories up - it is improbable that street dust contributed to the suspended sulfate levels.

2. The state has not run sulfate analyses on data more recent than that from 1971 from Anaconda stations. From February 7, 1971 to September 2, 1971 76 suspended sulfate analyses were made with an average of 3.21 ug/m^3. To date the Anaconda Company has refused to supply the department with its particulate data.

3. Anaconda Junior High is approximately 2.4 miles from the main stack of the Anaconda smelter. In this distance most "heavy" particulates would have fallen gravimetrically to the ground. Inasmuch as the bulk of Anaconda's

emissions come from the main stack it is highly probable that suspended particulates collected at the junior high school were from the stack. This does not rule out the possible collection of converter emissions during the same period of time.

4. For the period in 1971 corresponding in time to the above suspended sulfate data the State found for 97 separate 24-hour periods an average zinc concentration of 1.85 ug/m^3. Ammonia is ubiquitious in small concentrations in the atmosphere either in its free form or combined as a salt. Levels depend on the vicinity of natural or artificial decomposition processes. This information would at least allow the possibility of formation of such compounds in the Anaconda area as zinc ammonium sulfate.

There appears to be a strong correlation between air pollution concentrations and diseases of the respiratory tract. The death rate over a five year period (1968-1972) from lung cancer for Deer Lodge County is considerably higher than other Montana counties. Through application of the chi-square statistical test (43) the data for this period is highly significant. The probability that preditable lung cancer deaths for Deer Lodge County will approximate the state average is very small, according to statistical analyses.

The Bureau of Records & Statistics (43) has accumulated lung cancer mortality data over the five year period, 1968-72, and performed a chi-square test of significance comparing Deer Lodge County with the rest of the state. The test yields a value of 38.69. In the technique employed, a chi-square value of 10.83 means that the probability that such a difference could occur through the occurrence of chance factors is only one in a thousand; thus, the probability that the observed incidence of death from lung cancer in Deer Lodge County could be due to chance factors is extremely small. They conclude, therefore, that there is a factor or factors operating in Deer Lodge County which causes these relatively high death rates from lung cancer.

Figure 7 (43) graphically contrasts the lung cancer death rate for Deer Lodge County with that for the rest of Montana. In 1968 death rates for

Deer Lodge County, Montana and the United States were respectively 92.1, 28.4 and 29.7 deaths per 100,000 population.

Figure 8 (43) indicates that Deer Lodge County also has higher respiratory disease death rates than Montana in general.

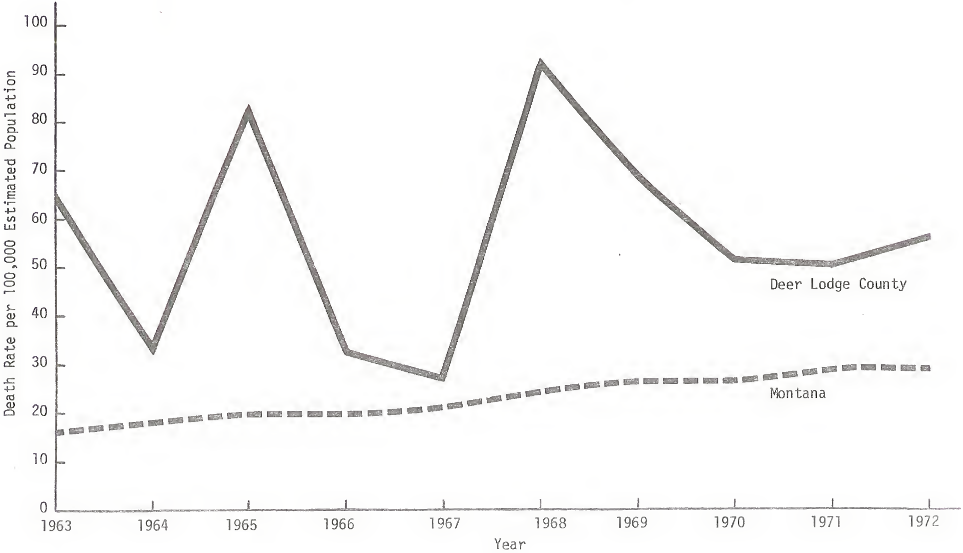
The relationship between respiratory disease and exposure to smelter emissions in northwest communities was studied in 1971 (44,45). The results of the studies generally were that chronic bronchitis prevalence and relative severity in non-occupationally exposure adult residents of two high exposure Rocky Mountain smelter communities (Anaconda, Montana and Kellogg, Idaho) significantly exceeded morbidity rates found in residents of communities subjected to lower exposures. Occupational exposure further increased observed bronchitis morbidity. Excess bronchitis occurred with 2 to 3 year exposure to SO_2 concentrations of 109 to 186 ug/m^3 (0.042 to 0.071 ppm at 27.92 in. Hg. and 77^oF) and suspended sulfate concentrations of 8.6 to 20.4 ug/m^3 in the presence of low total suspended particulates. Metallic sulfates may well have accounted for the findings of excess bronchitis (44).

> "Acute respiratory morbidity in asthmatic children began to increase with exposures to low annual average levels of sulfur dioxide (46 ug/m^3) (equivalent to 0.018 ppm) when moderately elevated levels of total suspended particulates (94-110 ug/m^3) were present. Unmistakably significant excesses in acute lower respiratory illnesses, especially croup, appeared amount asthmatic and non-asthmatic children exposed to higher pollution levels for 3 or more years. Such levels involve annual average sulfur dioxide levels of 109 ug/m^3 (0.042 ppm) accompanied by low annual average levels of particulates (43 ug/m^3) and minimally elevated annual average levels of suspended sulfates (8.6 ug/m^3). There was also suggestive evidence that more serious infections including pneumonia that might require hospitalization tended to be more frequent in children exposed to these elevated pollution levels" (45).

The nature of carcinogenesis with respect to air pollution can be somewhat clarified with the following general statements (46):

1. Cancer induction frequently requires prolonged exposure periods to carcinogenic agents.

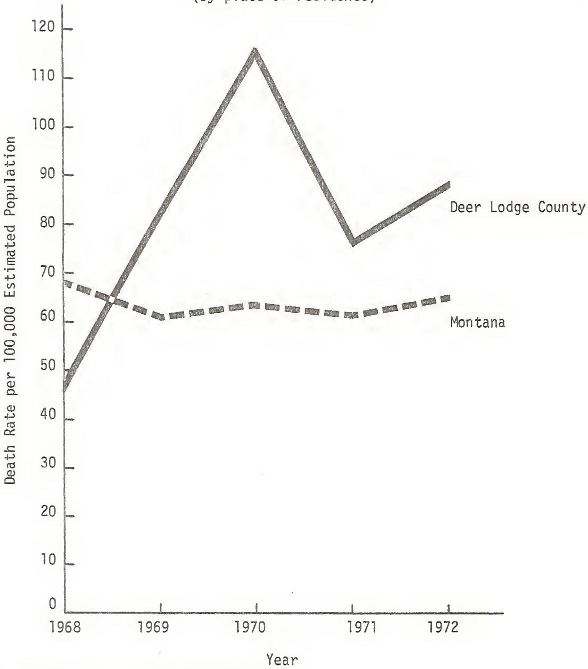
LUNG CANCER DEATH RATES: Montana and Deer Lodge County, 1963-72
(By place of residence)



Source: Bureau of Records and Statistics
Montana Department of Health and Environmental Sciences

Figure 7

RESPIRATORY DISEASE DEATH RATES,
Montana and Deer Lodge County 1968-72
(By place of residence)



Source: Bureau of Records and Statistics
Montana Department of Health and Environmental Sciences

Figure 8

2. Lung cancer can be caused by such agents acting in combination either additively, synergistically or in an inhibitory relationship to one another. Known carcinogenic agents include the metals beryllium*, arsenic and iron (36) all of which can be found in the Anaconda smelter area.

3. These agents act in lung cancer induction in proportion to the correlation of host defenses at the anatornic, physiological and biochemical levels. Some of the ubiquitous chemical and physical irritants near industrial sources although not necessarily carcinogenic facilitate the action of carcinogenic agents by attenuating or destroying the effectiveness of the mucociliary apparatus of the lining of the bronchiole tree. This action facilitates deposition and retention in the lungs of particles carrying carcinogenic agents. Sulfur dioxide also common to the Anaconda area is known to reduce nasal mucus flow - a function of ciliary action (38,41). In addition these irritants (eg., dust, fugitive gases, etc.) may alter the metabolic handling of carcinogenic agents and thereby enhance their cancer inducing potential.

4. There is evidence that at the cellular level, environmental chemical co-factors of a highly non-specific nature may work together with chemical carcinogens to increase their effectiveness in causing cancer (46).

5. Considering data generated by highly carionogenic occupational exposures and cigarette smoking it is somewhat difficult to generalize about the number of cancer cases as they relate to air pollution. Conversely researchers also have failed to provide evidence that a threshold exists for the action of a carcinogins (46). Dr. Carnow supports this with his view that any air pollution is too much (47) when health effects are considered, especially with regard to persons with poor adaptive capacity because of

---

*The Anaconda Company dismantled its pilot plant for extraction of beryllium from ore in 1973. The plant operated into the late 1960's.

serious lung disease, heart disease, asthma, or other serious chronic disease.

In summary, we should consider the comments made by Dr. Bertram Carnow before the National Academy of Sciences, October 3-5, 1973 (47).

This conculsions are as follows:

> "1. That SO_2 and particulates and, even more, their products sulfuric acid and acid sulfates are toxic and may seriously affect the health of significant numbers of humans, even at levels generally considered safe.
>
> "2. That the major target organs are the heart and lungs--and that therefore, large numbers of individuals in the population are at high risk.
>
> "3. That these pollutants may act over long periods of time to produce respiratory tract changes in normal individuals.
>
> "4. That their major action appears to be as a disease and death accelerator significantly shortening the lives of those with poor adaptive capacity.
>
> "5. That a highly variable dose-response relationship exists between SO_2 and particulate levels--and that in effect there is no threshold for health effects.
>
> "The outcome - health or disease, living or dying, depends on the number of environmental stressor and the intensity of each on the one hand and the resistance of the host and the ability to adapt on the other.
>
> "6. That the effects of other pollutants, cigarette smoking or heavy occupational exposure to irritant gases act synergistically with SO_2 and particulates--in no way diminish, indeed they enhance the need for adequate levels of SO_2 and particulate to protect health.
>
> "7. That the levels of SO_2 and perhaps other pollutants present in large urban areas today appear to leave significant numbers of people unprotected under conditions of inversion and stagnation."

D. Visibility

The extent of the direct effect on visibility by sulfur dioxide in the ambient air is presently unknown. However, sulfur oxides are oxidized to sulfuric acid and sulfates within an hour or two after being emitted to the atmosphere. The acid and sulfates do have an effect on visibility since they scatter and absorb light.

In urban air about 5 - 20% of the total particulate matter normally consists of sulfuric acid or sulfates (48). About 80% of the sulfuric acid and sulfates are usually below one micron in diameter. This particle size is within the range of 0.1 to 1.0 microns in diameter which has the greatest adverse effect on visibility.

At Anaconda, the amount of sulfate ion in suspended particulate is about 1-15% per analyses of Department of Health high volume samples taken at Deer Lodge, Ramsay, and the Anaconda Junior High School from February to May, 1971. Total suspended particulate ranged from 9.2 to 237 ug/m^3 per the same samples. These figures compare reasonably well with the data of Table 6.

No quantitative visibility measurements in the ambient air near Anaconda have been made but the visibility corresponding to the suspended particulate levels mentioned above are approximately 90 and 4 mi., respectively (49). Certainly the smelter at Anaconda which discharges 31 T./day of particulate matter and 713 T./day of sulfur dioxide must be considered a major contributor to any visibility reductions that occur in the Deer Lodge Valley.

E. Economics

1. The Anaconda Company

Business:

The following information was taken from Moody's Industrial Manual, 1973, and supplements to that manual issued periodically up to April, 1974 (50).

The Anaconda Company is a major industrial corporation engaged principally in non-ferrous metal mining, metal processing and manufacture of metal products. Copper, aluminum and uranium are the company's most important products. The company has mine-to-consumer capability in both copper and aluminum.

Anaconda provides materials for communications, mass transportation, environmental protection, power production and distribution, automobiles, industrial machinery and equipment, housing and construction and other basic areas.

Since 1971 expropriation of its properties in Chile, company's principal business interests are concentrated in the U. S. It does, however, have important investments in Canada, Mexico, Jamaica, Brazil and Australia. It now appears that Anaconda will probably receive a substantial reimbursement for the expropriated Chilean properties.

Anaconda produces a wide range of copper, brass and copper alloy products such as tube, sheet, strip and rod. Its wire and cable products include transmission and communications cable, magnet wire and CATV (Community Antenna Television) systems. Aluminum products include sheet, foil, extrusions, containers, residential siding and architectural products.

Anaconda mines copper in several western states and in Canada, produces alumina from bauxite in Jamaica, mines uranium in New Mexico and produces important amounts of silver, gold, molybdenum and other metals. Anaconda operates manufacturing plants at 47 locations in the U. S. and Canada.

mine production. Anaconda and Amax will jointly expand production, including the construction of a plant for treatment of oxide copper ore from the mine that will cost $59 million and will treat 10,000 tons of ore per day.

Subsidiaries:

Anaconda is both an operating and holding company, owning as of January 31, 1973, (except as noted) 100% voting control of the following principal subsidiaries:

Name and place of incorporation:

Anaconda Sales Co. (Del.)
Systems Wire & Cable, Inc. (Del)
Russell Anaconda Aluminum, Inc. (Del.)
Alsco Anaconda, Inc. (Del.)
Anaconda Canada Ltd. (Canada)
Anaconda International Corp. (Del.)
Anaconda Jamica, Inc. (Del.)
Greene Cananea Copper Co. (Minn.) (99.51%)

As of December 31, 1972, Anaconda omitted from its public record of subsidiaries, companies which, in aggregate would not constitute a significant subsidiary.

Other Investments:

As of December 21, 1972, Anaconda owned and controlled through a subsidiary, Mines Investment Corp., 26.68% of the outstanding stock of Inspiration Consolidated Copper Company.

Capital Expenditures and New Plants:

Capital expenditures for plant and equipment aggregated $122.6 million during 1972 compared with $89.9 million in 1971. The major portion of expenditures in both years were for construction of a new primary aluminum plant at Sebree, Kentucky and air pollution control equipment at the Anaconda copper smelter.

Joint Ventures:

Anaconda and American Smelting and Refining Company formed a joint venture in 1970 to explore and develop lead-zinc-silver reserves in Utah for United Park City Mines Co. This operation was inactive for several years but was reactivated in 1973. Milling will be done at the mine.

In June 1972, Anaconda and a group of concerns agreed to begin an exploration program over 340 square miles of mining claims in Australia. Search for minerals will be managed by Union Miniere Development and Mining Co., a subsidiary of Union Miniere S.A. Besides Union Miniere other companies undertaking work are LaPorte Mining Pty. Ltd., of Australia, and Mining Pty. Ltd., a subsidiary of TCL Australia. If exploration and development are completed as called for, these companies would "earn an undivided interest" in properties. Properties, situated in Western Australia, are 60% owned by Anaconda, 31% by Australian Mining and Smelting Co., and 9% by Metal Investigation Pty. Ltd.

In September 1972 Anaconda announced joining of Sar Chesmeh Copper Mining Co., of Kerman, owned by the Iranian government in a venture to develop copper deposits in Southeast Iran. Anaconda will provide technical help and training facilities to Sar Chesmeh on a fee basis during planning and construction period and for 10 years thereafter. Development of Sar Chesmeh properties is expected to cost $500,000,000 ultimately and to produce about 45,000 tons of blister copper yearly.

In 1972 an agreement in principle with American Metal Climax, Inc., was announced for its participation in Anaconda's Twin Buttes copper mine near Tucson, Arizona. Anaconda developed this mine and has operated it since 1969 under lease from Banner Mining Company, paying Banner a share of profits as royalties. Amax has agreed to purchase Banner's interest and will invest an additional $93 million in mine development over a three year period. Amax will acquire a one-half interest in the mine and will be entitled to one-half of

In 1973 and the first three months of 1974 the following events occurred:

1. A plant for treatment of oxide copper ores at Twin Buttes Mine near Tucson, Arizona was announced. The plant will cost $59 million and will require 2 years for construction. It is scheduled for completion in early 1975 (50).

2. In April, 1973, company began construction of a new hydrometallurgical plant for production of copper at Anaconda. The full-scale plant will cost $25 million and is expected to produce 36,000 tons of copper a year. It is scheduled for completion in late 1974 (50).

3. Anaconda Wire and Cable Company purchased Continental Wire and Cable Corporation from Hytronics, Inc., for $10.5 million and cancellation of other debts (50).

4. Anaconda will open an open pit mine in eastern Nevada in 1975. The ore will be concentrated at the mine and then shipped to Anaconda, Montana for smelting. The Arbiter plant at Anaconda will be expanded to process the additional feed. The new concentrator will have an input capacity of 1,000 T./day (50).

5. Anaconda has given Arthur G. McKee & Company a contract for a copper leaching facility at Sahuarita, Arizona (50).

6. On January 31, 1973, Anaconda acquired Russell Aluminum Corporation. The cost of this purchase was $13.7 million (50).

7. In February, 1973, Anaconda acquired Systems Wire & Cable, Inc., in exchange for 165,000 company common shares (50).

8. A subsidiary plans a $10.5 million expansion of its aluminum siding and extrusion plant at Gnadenhutton, Ohio (51).

Anaconda has had a continual increase in operating income (before extraordinary items) from 1971 to the present. In 1971 the operating loss was $6.2 million, in 1972 there was $44.1 million in income and 1973 saw a gain of 58% to $69.3 million. Earnings per share, before extraordinary items, has gone from a deficit of $0.28 in 1971 to $2.00 in 1972 and $3.16 in 1973.

Anaconda has also experienced a substantial rise in the measures of profitability, return on total capital and return on equity. According to Forbes Annual Industry Review (January 1, 1974) Anaconda's 5 year average increase for return on total capital was only 0.1% while its latest 12 month figure for the same index was 5.0%. Its 5 year average for return on equity actually decreased while the latest 12 months figure was 5.9% increase. These latest 12 months figures are for 1973 during which copper prices were at an artificially low level due to price controls. They are 16% higher today than one year ago. 1974's figures, due to decontrol, should show a substantial increase over 1973's.

The Primary Metals Division, recently reorganized and now called the Metallurgical Division, provided about 30% of company sales in 1971 and 1972. This amounted to $359.9 million in 1972 and $344.9 million in 1971.

The Anaconda Company has paid dividends to stockholders every year since 1900 with the exception of 1921, 1922 and 1932 through 1935.

TABLE 10

SIX -Year Financial and Operating Summary (50,52)

For the year ended December 31 (millions of dollars):	1973	1972	1971*	1970	1969	1968
Sales and other operating revenue	1,343.1	$1,011.6	946.5	977.4	1,410.6	1,051.0
Depreciation and depletion	45.6	44.1	46.9	44.2	49.9	50.5
Income (loss) before extraordinary items	69.8	44.1	(6.2)	72.3	102.3	89.5
Extraordinary gain (loss)	18.3	88.9	(347.6)	(4.3)		
Net income (loss)	88.1	133.0	(353.8)	68.0	102.3	89.5
Dividends paid	11.0	2.7	10.9	41.6	48.2	49.3
Capital expenditures for plant and equipment		122.6	89.9	90.5	127.0	153.8
At December 31 (millions of dollars):						
Working capital	261.4	$291.0	266.0	291.9	261.6	361.1
Long-term debt (due after one year)	252.4	278.1	391.5	366.5	305.6	277.1
Shareholders' equity	1,048.1	971.4	840.8	1,205.6	1,179.2	1,124.8
Common shares outstanding	22,069.3	22,055.8	21,890.8	21,891.6	21,891.2	21,886.2
Per share of common stock:						
Income (loss) before extraordinary items	3.16	$ 2.00	(.28)	3.30	4.67	4.09
Extraordinary gain (loss)	.83	4.03	(15.88)	(.20)		
Net income (loss)	3.99	6.03	(16.16)	3.10	4.67	4.09
Dividends paid	.50	.125	.50	1.90	2.20	2.25
Shareholders' equity	47.49	44.04	38.41	55.07	53.87	51.39
Primary Production (in short tons):						
Copper		242,955	227,415	282,413	598,241	554,829
Aluminum		177,618	171,677	177,257	176,767	119,892
Uranium (U_3O_8)		2,022	1,763	1,767	1,521	1,567

*Losses in this year were caused by the expropriation of Anaconda's assets in Chile.

2. The Copper Industry

An economic profile of the copper industry is described quite well in Reference 11, "Background Information - Proposed New Source Performance Standards for Primary Copper, Zinc and Lead Smelters." That portion of Reference 11 is included in Appendix D of this document. Another good source of information on this subject is Reference 53, "Economic Impact of Anticipated Pollution Abatement Costs on the Primary Copper Industry," which was used in the preparation of Reference 11.

The key points about the copper industry from Appendix D (Ref.11) are that:

1. The Anaconda Company produces about 12.4% of this nation's refined copper.

2. Five companies, including Anaconda, market approximately 85% of the nation's refinery production.

3. Anaconda is one of the extensively integrated companies in that wholly owned mine output provides a large proportion of the smelter feed. Also, Anaconda not only markets refined copper, but a large variety of manufactured copper products. Anaconda and three other companies account for over 50% of sales by wire and brass mills.

4. "In terms of U. S. trade balance, this country is a net importer of refined and semi-refined copper, as shown by the 'additions to domestic supply' column in Table 6-5. The net imports for the most recent ten years has normally ranged from 6 to 10 percent of total refined supply. During the period of shortages in 1967 and 1968, imports accounted for 20 percent of refined supply.

"The domestic tariffs on primary copper products has generally been low. Currently, refined copper imported in the United States is assessed with a tariff of $0.008 per pound. Ores, blister, anode, and scrap are essentially duty-free. However, there are quota limitations on exports. In 1969, exports of refined copper from domestic sources and scrap were limited to 50,000 and 60,000 short tons, respectively. Foreign tariffs on primary copper products are also generally low. Many countries, such as Scandinavia, Austria, Switzerland, and those of the European Economic Community admitted unwrought copper duty-free. In Britain, tariff has ranged from zero to 10 percent ad valorem."

5. It appears that in the next few years there will be a shortage of smelter capacity in this country. If this does occur, foreign imports of

refined material may be expected to increase along with higher prices. An additional capacity of 400,000 to 700,000 Tons/yr. will be needed by 1980.

6. "Based on the performance of the U. S. economy in general for the last 10 years, an assumption of a 3 percent growth rate seems reasonable in light of the expected annual 4 percent rate of increase in real growth through 1980 by the Department of Commerce."

7. Mining costs range from 23-40 cents per pound of metal. The smelter-refiner adds about 10¢/lb. which is constant regardless of fluctuating copper prices.

An important economic practice outlined below is contained in Reference 53. It states:

"An important aspect of the entire primary non-ferrous industry is that traditionally the smelters and refineries have been operated as service operations at a fixed and relatively low profit margin which is not very sensitive to the price of the finished product. Hence, the impact of any change in price of the primary metal has to be reflected back and affects directly the value of the concentrate. In the 1960's, the traditional rule-of-thumb in determining concentrate value in the copper industry was to assume 4¢/lb. for smelting charges and 5¢ for refining charges so that the value of copper contained in the concentrate is very approximately 9¢/lb below the cathode or wirebar market price. (The current operating margin in the copper industry is about 10¢/lb., in the lead industry about 4-6¢/lb--and complicated by co-produce values--and that in the zinc industry is about 8-10¢/lb.).

"Because of this mechanism, any increase in smelting or refining costs cannot be 'absorbed' by the smelter or refinery but can only be passed backward to the mine and the net-back (the net concentrate value realized at the mine; e.g. smelter payment minus transportation costs) would be decreased. Should the market supply/demand constraints permit an upward adjustment in primary metal price, this increase would then be reflected back to the mine. The mechanism described above is of primary importance to custom and toll smelters since it is possible that a decreased concentrate value can result in mine closings and loss of smelter feed material.

"However, essentially the mechanism operates in the case of producers integrated from mining through smelting and refining since the concentrate transfer price is related to the primary metal price and again the mines would have to absorb the increased smelting and refining costs under adverse market conditions.

"During the 1960's, the annual average copper (f.o.b. domestic refinery) price varied from a low of 29.9¢ per pound in 1961 to a high of 57.7¢ per pound in 1970. During 1970, the price was 59.7¢ per pound for about four months. The price variation in 1972 until October was 2.25¢ per pound, the late October price being 49.985¢ per pound. The prices on the London Metal Exchange have traditionally been much more volatile. (38)"

Since the preparation of the portion of Appendix D entitled "Copper Industry Economic Profile," the federal government deregulated copper prices which allowed them to increase. The three prices of copper used in Appendix D, the London Metals Exchange (LME), New York Commodity Exchange (COMEX) and Number 2 scrap pare presently about 132.¢/lb, 69.25¢/lb. and 100.¢/lb (54). The present COMEX price is about 33% higher than the COMEX value of 52¢/lb used in the preparation of Reference 11. This fact should be kept in mind when reading that portion of Appendix D.

Production costs surely have also risen since preparation of Ref. 53 in the spring of 1972, but since this information is considered proprietary by industry and can vary widely from company to company, no accurate estimate for The Anaconda Company can be given. The sale price of refined copper for a "high cost integrated producer" are estimated to be 52¢/lb of copper per Reference 11 which was prepared in 1973. Reference 53 indicates production costs (from mining to primary metal) vary from about 33¢/lb to 50¢/lb.

> "In a plant-by-plant and company-by-company analysis of pollution abatement impact, two viewpoints have to be considered. The availability of capital for pollution abatement equipment at each plant has to be viewed from the standpoint of the resources available to the entire corporation. However, the justification for spending this capital at a particular plant would result from a study of that particular plant's economics which would take into account alternatives such as the cost of production from a refitted plant, shifting production to other plants, and most important, the probability that this particular plant will remain a profitable entity. (53)"

The non-ferrous metals industry showed very strong sales and earnings per share growth in 1973 as compared to 1970-72. The sales increase averaged 28% and earnings per share (EPS) increase averaged 29%. What shows economic strength is that the EPS figure equalled the sales figure, even though price controls kept the metal prices substantially below what they are today. 1974 should show improved earnings across the board.

Forbes Magazine, January 1, 1974 (pp. 150-152) describes the present copper market as follows (55):

"For physical, for political, for economic reasons, copper and zinc are and have been in short supply, and relative to steel and aluminum they are likely to remain so. Shortages spell higher prices, and higher prices are likely to mean higher profits."

"Aluminum and steel reflect the economics of abundance, but the other metals tend to reflect the economics of shortage, perennial if not necessarily permanent."

The future of the copper industry is economically sound, primarily because of the physical nature of copper and the basic supply and demand forces at work.

"The production figures tell the story: U. S. steel production at 150 million tons is almost 10 times that of all the nonferrous metals combined. By the same token, U. S. aluminum production--at 4 million tons a year--runs around twice that of copper, three times that of lead, five times that of zinc.

"The differing physical properties of the various metals explains part of the difference. But they are also lower volume because they are higher priced, and they are higher priced because they are relatively rare. These are not precious metals--not gold, silver or platinum, where quantities are measured in ounces rather than pounds. But they are more precious than those that are measured in tons. Which is why copper and zinc and lead, unlike iron, steel, nickel, bauxite or aluminum, are traded on the London Metal Exchange--the world's great market for hedging against shortages. And this is also why the average return on investment in these metals has also been so markedly superior to steel and aluminum. They are inherently more valuable, and hence yield higher profits.

"Mining men, of course, do not see things this way. Quite properly, they see only the economics of individual mines, but the correlation between metals produced and profits earned is at least as persuasive as the correlation between smoking and cancer. Among the mining outfits in the FORBES list, the most profitable companies in return on capital are those that are heavily committed to copper--Newmont Mining, Cyprus Mines, Phelps Dodge, American Smelting & Refining. Together, they average over 12% on their invested capital, or twice that of steel and aluminum. Add in Kennecott, with its heavy commitment to coal; International Nickel; Anaconda, with its big commitment to such sidelines as aluminum, lead and zinc; and Cerro, with a wide range of diversified businesses, and the average still runs around 10%. Little wonder that oil companies like Pennzoil, Cities Service and Standard of Indiana have been eager to get into copper. Little wonder, too, that American Metal Climax, faced with the loss of its Zambian investments, has been trying to get into the domestic copper mining business for years."

"Given the experience of the past, there is every reason to expect that the demand for metals is going to continue to rise, and that the same pressure of shortages on prices that has made copper and zinc more attractive areas for investment than aluminum and steel is going to continue, though the pressure points of the past are not necessarily going to be those of the future."

The cost of controlling the sulfur oxide emissions is discussed in Section II F above.

F. Socio-Cultural

The Anaconda Company smelter is located at the south end of the Deer Lodge Valley on the east edge of the town of Anaconda. The valley extends about 30 miles to the north and is bordered on the east by the Deerlodge and Helena National Forests which are located on the Continental Divide. On the west side is the Flint Creek Range which is also part of the Deerlodge National Forest. The mountainous areas have many peaks exceeding 8,000 feet elevations.

To the southeast of Anaconda is a valley leading to Butte. To the south, southwest and west of Anaconda are the Deerlodge and Beaverhead National Forests. Numerous peaks in these mountains exceed 10,000 feet elevation. The Continental Divide passes through this area also. The Anaconda-Pintlar Wilderness Area is about 15 miles Southwest of Anaconda.

There are many lakes in the mountains around Anaconda. The best known of these are Georgetown, Silver and Echo. The natural resources available for fishing, hunting, and other outdoor activities are excellent in this area. Outdoor activities can be enjoyed year-round.

Because of a major cross-county highway passing through the valley, summer tourist trade is important to some valley residents.

Tourists and residents alike can enjoy the natural beauty of the mountains, lakes and forests. In addition, there are smelter tours, mine tours, a resort with hot water pools, and quite an interesting local history, the remnants of which are still partly visible in the area.

A large portion of the land in the Anaconda vicinity is either forest, range, or federal non-crop land. The distribution of this land by use is as follows (56):

	Powell Co.	Deer Lodge Co.	Silver Bow Co.
Forest	293,886 acres	119,567 acres	49,490 acres
Range	361,697 "	146,860 "	147,371 "
Pasture	26,012 "	8,293 "	2,000 "
Cropland	71,612 "	16,892 "	5,980 "
Other	6,446 "	1,905 "	1,468 "
Total Agricultural	759,653 "	293,517 "	206,309 "
Small Water Areas	8,000 "	500 "	411 "
Urban	14,114 "	19,951 "	13,316 "
Fed. Noncropland	713,913 "	158,352 "	238,204 "
Total	1,495,680 acres	472,320 acres	458,240 acres

On a tri-county basis the land is used as follows (56):

Forest	19.08%	462,943 acres
Range	27.03%	655,928 "
Pasture	1.49%	36,305 "
Cropland	3.89%	94,484 "
Other	0.40%	9,819 "
Total Agricultural	51.89%	1,259,479 "
Small Water Areas	0.37%	8,911 "
Urban	1.95%	47,381 "
Federal Noncropland	45.76%	1,110,469 "
Total	99.97%	2,426,240 acres

The Deer Lodge Valley is the populated area most affected by the smelter emissions. This land is primarily agricultural, although a significant amount is taken up by settling ponds and urban areas. The agricultural areas are used for range land, pasture, and crops. Hay is the most widely grown crop since livestock is the most important agricultural product of the valley (56). Additional information on crops and soil can be found in Section III B.

The following areas near Anaconda Company facilities have the following populations per 1970 census figures:

Anaconda	9,770	Black Eagle	2,200
Warm Springs	500	Great Falls	60,100
Galen	50	Cascade County	81,800
Deer Lodge	4,310		
Deer Lodge Co.	15,650		
Butte	23,370		
Walkerville	1,100		
Silver Bow Co.	41,980		

No population figures for the communities of Opportunity, Silica, Sunnyside and Crackerville, all Anaconda suburbs, could be found.

Educational opportunities in the Anaconda area are comparable to other areas of the state. Anaconda and Deer Lodge each have a high school while Butte has two. Butte also has two junior high schools, nineteen grade schools, and Montana College of Mineral Science and Technology. Anaconda has one junior high school, and six grade schools. Deer Lodge has a junior high school and three grade schools. There are grade schools in Opportunity, Warm Springs, Rocker and Ramsay.

Hospitals are located in Butte (two), Anaconda and Deer Lodge. The hospitals at Galen and Warm Springs have special purposes and therefore are used by a very small percentage of the general public.

Major employers and approximate number of employees in the Butte-Anaconda-Deer Lodge area include:

The Anaconda Company, Butte, 3500 employees (8)
The Anaconda Company, Anaconda, 1600 employees (8)
Warm Springs State Hospital, 700 employyes, 1150 patients
Montana College of Mineral Science & Tech., 160 employees, 700 students
Montana State Prison, 230 employees, 339 inmates
Galen State Hospital, 235 employees, 300 patients
Montana Power Company, 500 employees
The Milwaukee Road, 375 employees
Mountain Bell, Butte District, 256 employees
Montana State Highway Department, 225 employees (in 7 counties)
Stauffer Chemical Company, 214 employees
The Montana Standard, 90 employees
Burlington-Northern Railroad, 80 employees

The Anaconda Company plants at Anaconda and Great Falls, The Montana Standard in Butte, and Stauffer Chemical Company at Ramsay are among the 50 largest manufacturers (by employment) in Montana (57).

In addition to the employers listed above, the towns in the Anaconda area have the usual assortment of small companies, businesses, professional people, schools, municipal employees, construction workers, etc. Employment in the outdoor occupations naturally slows down in winter due to adverse weather conditions.

Employment at the different Anaconda Company operations in the Butte-Anaconda area are approximately as follows (8):

Anaconda Operations	1600 employees
Berkeley Pit	1520
Continental East Pit	105
Deep Mines	830
Office workers	200
Weed concentrator	310
Miscellaneous	535
Total	5100 employees

In addition, the copper refinery and wire plant at Great Falls employ about 650 persons.

Present Anaconda Company employment in Montana, excluding the aluminum operation, is about 2.0% of the total labor force of 298,400 (58). Anaconda Company employment in Silver Bow County is about 19.5% of the 17,980 average labor force of 1973 (59). The Deer Lodge and Cascade County percentages are 26.1% and 2.4% based on labor forces of 6,130 (1973 annual average) and 30,900 (February, 1974) (59).

A substantial number of company employees have been assigned to work on the installation of systems and plant modifications associated with air pollution control measures and devices. In addition, during the past three years contracts have been let for work to be done by outside employment forces. Additional air pollution control facilities, measures and devices would result in the employment of still more persons, although the number of new employees needed cannot now be predicted accurately.

The Anaconda Company is the largest property tax payer in Silver Bow and Deer Lodge Counties. The company's property tax payments in these two counties are about $3.3 million and $1.5 million, respectively. The company also pays property taxes of approximately $643,000 to Cascade County, approximately $43,000 to other counties and pays a metals mine tax of some $1.8 million to the state each year (8). Table 11 also shows some pertinent property tax information.

TABLE 11

Anaconda's Contribution to Local Property Tax Revenues in 1973

	Total Money Paid ($)	Paid by The Anaconda Co. ($)	Approximate % Paid by The Anaconda Co.
Property Taxes Received by Deer Lodge County	3,259,606 (Fiscal 72)	1,510,400 (Calendar 72)	46.3
	3,501,120 (Fiscal 73)	1,815,528 (Calendar 73)	51.9
Property Taxes Received by Silver Bow County	11,769,093 (Fiscal 72)	3,026,336 (Calendar 72)	25.7
		3,269,053 (Calendar 73)	-
Property Taxes Received by Cascade County	18,003,573 (Fiscal 73)	643,000 (Calendar 73)	3.6
Property Taxes Received by all Montana Counties	219,101,201 (Fiscal 74)	5,889,263 (Calendar 73)	~ 2.7

Note: This information was obtained from the Department of Revenue, State of Montana and Reference 8.

G. Energy Consumption

The information contained in this section is based on actual 1973 production of copper at the smelter. During this time period the average production rate was 30.2 million pounds of copper per month or 86.2% of the rated smelter capacity. This fact should be kept in mind when studying the quantities of energyused.

Total electric power consumption at the Anaconda Reduction Works, based on the first nine months of 1973 was 381,000 kilowatt-hours per day (KWhrs/day), 11.6 million KWhrs/mo., or 139 million KWhrs/yr. Of these total figures, about 60% or 241,000 KWhrs/day are directly used for the smelting of copper (3). This power is used in the different areas of the smelter in the following proportions (2):

Electrostatic precipitator in main stack	375,000	KW Hrs/mo
660 T./day sulfuric acid plant	1,375,000	"
Transportation	35,000	"
Lime kiln No. 1	180,000	"
Lime kiln No. 2	555,000	"
Limestone quarry	30,000	"
Silica quarry	-	
Foundry	60,000	"
Roaster building No. 1	10,000	"
Roaster building No. 2	105,000	"
Reverberatory furnaces, converter and casting area	4,500,000	"
Miscellaneous	4,375,000	"
Total	11,600,000	KW hrs/mo

Natural gas used at the smelter is as follows (2). These figures are also based on 1973 production except for miscellaneous which is from 1972 data. The gas quantities used are:

Roaster No. 2	30,100,000	ft.^{3}/mo.
Reverberatory furnaces, converters and casting area	575,000,000	"
Foundry	7,000,000	"
Transportation	500,000	"
Acid plant	50,000	"
Lime kiln No. 1	50,000,000	"
Lime kiln No. 2	115,000,000	"
Electrostatic precipitators in main stack	250,000	"
Miscellaneous (9)	130,350,000	"
Total	908,250,000	"

Fuel oil and gasoline consumption at the smelter are shown below (2):

	Gasoline	Fuel Oil
Transportation	9,000 gal/mo	68,000 gal/mo
Limestone quarry	500 gal/mo	1,000 gal/mo
Silica quarry	1,000 gal/mo	500 gal/mo
Foundry	300 gal/mo	100 gal/mo
Reverberatory furnaces, converters, and casting area	150 gal/mo	-
Total	10,950 gal/mo	69,600 gal/mo

Consumption of fuel oil in the furnace area is for emergency use only and is used at a rate of 1,670 gal/hr.

In addition to the power consumptions given above, the Butte operations of The Anaconda Company uses 53 million KW hrs/mo of electric power, 36,000 ft.^{3}/mo of natural gas, 58,000 gal./mo of gasoline, and 1,310,000 gal./mo of fuel oil (2,60). These figures are again based on 1973 production. The copper refinery and wire plant at Great Falls use about 132 million ft.^{3}/mo. of natural gas, 7 million KW hrs./mo. of electrical power, and small amounts of gasoline and fuel oils (8).

The overall energy efficiency of electric smelting compared to reverberatory smelting is an impending energy consumption change which should be discussed. The electrical power requirement of an electric smelting furnace sized to smelt 2,000 T./day of dry copper concentrates is approximately 40,000 Kva. Power consumption of this order of magnitude would normally be sufficient for a city of some 40,000 people (11). Reference 11 states:

> "The thermal efficiency of electric furnaces, with regard to providing the heat necessary for smelting, is higher than that of reverberatory smelting furnaces. In electric furnaces there are no combustion gases, only gases resulting from the smelting reactions, the vaporization of water and air infiltration. Consequently, the volume of off-gases from electric furnaces is typically an order of magnitude less than that from reverberatory furnaces. Furthermore, the temperature of the off-gases from electric furnaces is typically within the range of 800-1100°F., while the temperature of the off-gases from reverberatory furnaces is typically within the range of 1800-2200°F. As a result, the heat lost

> to the furnace off-gases is mugh higher in a reverberatory furnace than in an electric smelting furnace. Thus, the thermal efficiency with regard to smelting for reverberatory furnaces is normally only 25-30%, while that for electric furnaces is normally 60-65%.
>
> "If, however, reverberatory furnaces and electric furnaces are viewed with regard to the overall efficiency of energy utilization, reverberatory furnaces are more efficient than electric furnaces. Although half of the input energy to a reverberatory furnace may be lost to the off-gases from the furnace, the recovery of waste heat from these off-gases is normal practice. Thus, the overall efficiency of energy utilization for reverberatory furnaces is in the range of 55-60%. Taking into account the efficiency of conventional power generation (from 35-40%), the overall efficiency of electric furnaces with regard to energy utilization is only 20-25%" (11).

As mentioned above, the overall efficiency of reverberatory furnaces without waste heat recovery is about 25-30%.

Since The Anaconda Company does not recover heat from the reverberatory furnace off-gases, the overall efficiency of the electric furnace might be a little less than the existing reverberatory furnaces. This fact is offset by the fact that it will reduce production cut-backs caused by interruption of natural gas service.

H. Raw Materials and Other Natural Resources

Silica rock is currently being used at a rate of about 120 to 320 T/day or 54 to 144 cubic yards per day (yd^3/day). This material is removed from the quarry about 3 miles southwest of the smelter complex (6).

About 1,250 T/day or 504 yd^3/day of limestone is produced at the quarry west of town (6).

The Butte concentrates and precipitates require the mining of 50,000 T/day of ore from the Berkeley Pit and 2,700 T/day from the deep mines (2). Approximately 185,000 T/day of waste and leach rock are removed from the Berkeley Pit (2). About 14,000 T/day of ore are being removed from the Continental East Pit (10). This operation began quite recently; substantial amounts of waste material are removed from the operation.

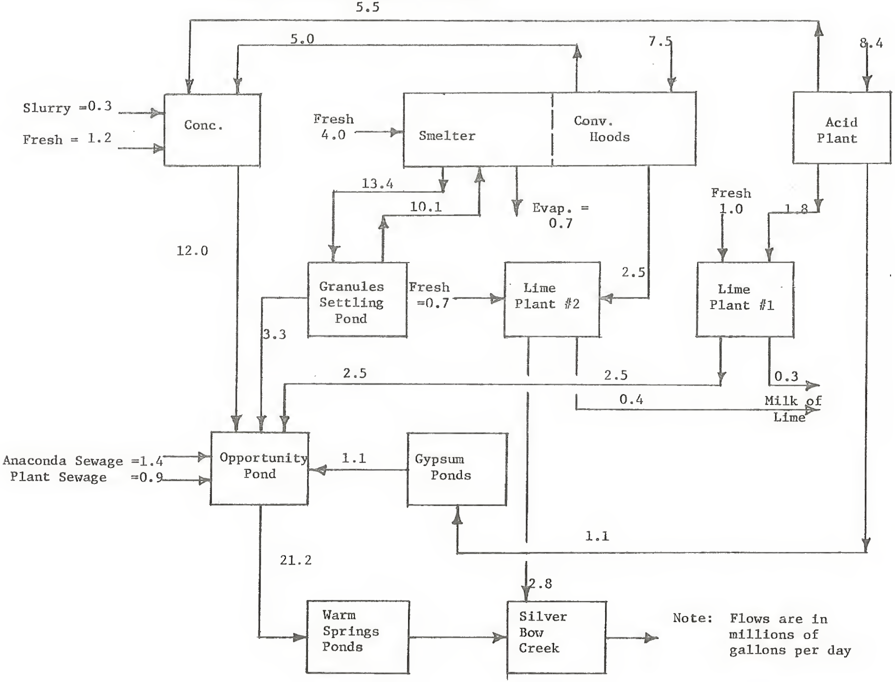
I. Water Quality

The water utilizing and wastewater producing facilities presently in use at the Anaconda Reduction Works include the concentrator, smelter, smelter acid plant, and two lime plants. The flow rates described below are also shown in Figure 12.

The concentrator uses approximately 12.0 million gallons per day (MGD) of water of which 1.2 MGD is fresh water. Recycled cooling water from the acid plant and the converter furnaces provides 10.5 MGD used at the concentrator. The remaining 0.3 MGD accompanies the concentrates from the Butte operations. The concentrator discharges approximately 12.0 MGD of wastewater (tailings plus the thickener overflows) to the Opportunity ponds.

The smelter uses approximately 21.6 MGD of water of which 11.5 MGD is fresh water and 10.1 MGD is recycled water from the granulation water clarification ponds. The converter hood cooling water is recycled at a rate of 5.0 MGD to the concentrator and 2.5 MGD to lime plant no. 2. The slag granulation water is discharged to the granulation water clarification ponds

Figure 12. Water Usage at Anaconda Reduction Works, Anaconda, Montana



Note: Flows are in millions of gallons per day at a rate of 13.4 MGD. With the recycle of 10.1 MGD from these ponds, a net overflow of 3.3 MGD is discharged to the Opportunity ponds.

The smelter acid plant uses approximately 8.4 MGD of water consisting entirely of fresh water. The acid plant cooling water, 7.3 MGD, is recycled at a rate of 5.5 MGD to the concentrator and 1.8 MGD to lime plant no. 1. The remaining wastewater from the acid plant, a total flow of 1.1 MGD from the mist precipitators, scrubbers, hot fans, and acid plant is discharged to the gypsum pond. The gypsum pond overflows to the Opportunity ponds.

The classification of the Clark Fork River below Garrison is B-D_1 which means the waters shall be maintained suitable for drinking, culinary and food processing purposes after adequate treatment equal to coagulation, sedimentation, filtration, disinfection and any additional treatment necessary to remove naturally present impurities; bathing, swimming, and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; agricultural and industrial water supply.

Clark Fork River near Galen on April 19, 1973

Stream Flow	99 cubic feet per second (cfs)
Water Temperature	7.0°C
pH	8.3
Dissolved Oxygen	10.6 milligrams per liter (mg/l)
Biochemical Oxygen Demand	3.5 mg/l
Phosphorous (total)	0.04 mg/l
Nitrate & Nitrite total as N	0.29 mg/l
Nitrogen total as N	0.94 mg/l
Calcium	150 mg/l
Magnesium	18 mg/l
Sodium	16 mg/l
Chloride	8.1 mg/l
Fluoride	1.3 mg/l
Sulfate	380 mg/l
Coliform Bacteria	10/100 ml
Fecal Coliform	0/100 mg

April 18, 1972

Stream Flow	221 cfs
Arsenic	0.010 mg/l (total)
Cadmium	0.004 mg/l (total)
Copper	0.020 mg/l (total)
Iron	0.670 mg/l (total)
Lead	0.012 mg/l (total)
Zinc	0.230 mg/l (total

The principal sources of nitrogen in the Clark Fork River at this time are probably from the Butte "metro" treated sewage discharge and the Anaconda fish hatchery.

The Department is presently planning to take and analyze samples monthly from the Warm Springs pond discharge and from the Clark Fork River below Warm Springs Creek and below the Little Blackfoot River. The small amount of sampling information presently available indicates that the state's water quality standards are being met by The Anaconda Company. However, there is need for more data.

J. Effects on Materials

Much of the damage to materials is actually caused by sulfuric acid formed by the oxidation and hydration of sulfur dioxide in the atmosphere. It has been found that sulfur dioxide in concentrations of 0.1 to 0.2 ppm can damage certain paint pigments. Carbon steels, zinc, copper, aluminum and stainless steels, in order of decreasing sensitivity, are damaged by oxides of sulfur, especially at high relative humidity or high temperature. The effects on mild steel were found at concentrations below 0.04 ppm annual average. Sulfur oxides are also detrimental to portland cement, various stones, paper, leather and textiles. Textile fading studies have shown damage at annual average concentrations of 0.09 ppm sulfur dioxide (61,62).

IV. POSSIBLE ACTIONS BY THE DEPARTMENT OF HEALTH AND ENVIRONMENTAL SCIENCES

A. The Director may recommend that The Anaconda Company variance be granted by the Montana State Board of Health as requested. The granting of any variance is permitted under Montana law only if the impact of such action neither endangers the public health nor endangers the public safety and, further, only if such action results in greater public benefit than public hardship to the citizens and State of Montana. Therefore, granting the variance would require the conclusion that The Anaconda Company's continuing, unabated violations of Montana's Clean Air Act and the regulations enacted thereunder are a danger neither to public safety nor to public health. Moreover, such action would also require the conclusion that the state is benefited more, or the hardship is less, from such continuing violations of Montana's air pollution laws than from compliance with the law.

B. The Director may recommend the denial of that variance request. No variance shall be granted except after a public hearing held after proper notice and until the Board of Health has considered the relative interests of the applicant, other owners or property likely to be affected by the emissions and the general public. A variance is not a right of the applicant but shall be at the discretion of the Board. The Board can justifiably deny the variance after considering the facts established in the preceding sections of this statement. Further considerations to be weighed before making a decision to deny the variance are:

1. Does the regulation set a reasonably achievable standard?
2. Are reasonably effective control systems available?
3. Do pollution control systems which will meet the standard require unreasonable economic expenditures?
4. Does pollution control produce counter-productive environmental effects of greater magnitude?

5. Is the public health or safety in jeopardy unless the variance is denied?

6. Does public hardship exist if the variance is denied?

7. Does public benefit equal or exceed the public burden if the variance is denied?

V. IMPACTS OF POSSIBLE ACTIONS

A. Grant the Variance as Requested

If the Company's variance request was granted, adverse environmental effects on air and water quality, vegetation, materials, and people would continue, although these adverse effects could be reduced somewhat by the Company's program to bring the acid plant up to its 660 T/D capacity with the possibility of eventually adapting it to generate up to 990 T/D. Community economics, the social and cultural atmosphere would not change. Corporate economics would benefit through reduced control expenditures.

The company does not propose a program to achieve compliance with the existing emission regulations at any time. The existing adverse environmental effects caused by SO_2 violations are described in the preceding sections of this statement and report. Adverse environmental effects would continue to endanger public health, safety, and property. The original adoption of the state sulfur emission regulations and the rejection of The Anaconda Company's request for changing these regulations in 1971 was based on the need to relieve the public of the well established ill effects of sulfur oxides in the air.

The Department has concluded that granting the variance would continue to endanger the public's health and safety and to damage property to an extent overshadowing any possible benefits.

B. Deny the Variance

If the variance were denied, and The Anaconda Company chose to close the smelter, the effect on energy consumption, material usage and water quality would be significant. There would be tremendous amounts of natural gas, fuel oil, gasoline, and electrical power available for other uses or conserved for later use.

Copper ore and silica rock would not have to be mined, although a more important aspect of these operations may be the energy required, not additional scarring of the natural terrain. Limestone might still have to be mined, but in smaller quantities.

No one can deny that a smelter closure would improve air quality, effects on vegetation, materials and humans, and conserve raw materials and energy.

The effect of a smelter closure on water quality is not as clear-cut as the other effects. If the Butte operations continued, neutralization of Silver Bow Creek would still be mandatory to maintain water quality. If the Butte operations closed along with the smelter, neutralization of Silver Bow Creek might be unnecessary. Because the town of Anaconda utilizes the company ponds for sewage disposal, the city would probably have to assume responsibility for operation of the ponds.

It is clear that the company can achieve compliance with the applicable regulations. The cost of such compliance is not unreasonable (Appendix D, Ref. 11) and the present economic status of the company does not preclude compliance. If the company does not voluntarily comply, Department enforcement action would be necessary. Voluntary compliance would have very little adverse environmental impacts. Involuntary compliance might be more time consuming for the state and the public, but otherwise would have very little adverse environmental impact.

If the variance is denied and Anaconda brought legal action rather than agreeing to achieve compliance, the smelter could continue to operate and pollute in excess of the standard for an indefinite time. Adverse environmental impacts would thus continue unless smelter operations were curtailed. A smelter closure would be a hardship on some part of the public, although it would have a better environmental effect than full compliance with the sulfur oxide pollution control standards. However, because a smelter closure would also deny The Anaconda Company a substantial source of income, the possibility of closure is extremely remote.

VI. PROPOSED ACTION BY THE DEPARTMENT OF HEALTH AND ENVIRONMENTAL SCIENCES

In the draft EIS the Department of Health and Environmental Sciences stated its recommendation that the requested variance be denied. After further research and following consideration of the comments received in response to that draft, the Department reaffirms that recommendation.

Contrary to the Company's present argument that it is economically and technically unfeasible to control sulfur oxide emissions to the degree required to meet the standards, on June 18, 1971, Mr. M. K. Hannifan, Vice President of the Primary Metals Division of Anaconda, wrote to Ben Wake, Administrator of the Environmental Sciences Division, and affirmed the Company's ability and intention to install equipment with then existing technology that would have brought the SO_2 emissions within the state standards. Those standards include 90% sulfur retention. The 1971 willingness and ability to comply was based primarily on the conversion of SO_2 into sulfuric acid.

The technical capacity to restrict all but 10% of sulfur emissions remains available. Rather than insist that the Company comply immediately with the standard the Department would prefer to see the adoption and employment of the necessary technology in scheduled increments to avoid the economic impacts that could result if immediate compliance were required. The Department does not propose arbitrarily to enforce state SO_2 emission standards without first employing or attempting to employ what in effect is an industry "affirmative action" plan.

Certainly the position taken by the Company covers much broader ground than variance petition. The Company's essential request is that the standards fixed should be regarded as inapplicable to The Anaconda Company for the foreseeable future. The Department cannot recommend such a request be allowed for anyone.

Measured sulfur compounds in the atmosphere and environment around the Anaconda smelter exceed both state and federal levels of tolerable toxicity. Those levels are set at the maximum permissible to guard, first, public health, then other animal and vegetative life, and the remainder of our environment. Emissions which result in measured levels in excess of state and federal standards must be reduced. The policy of emission restriction under Montana law and regulations is to avoid allowing the deterioration of air quality to the ambient standards when lower emission levels are technologically attainable.

This final environmental impact statement should be summarized by drawing conclusions on the criteria which test a variance application:

1. Human health is endangered by levels of emissions at which The Anaconda Company operates.

2. In the Deer Lodge Valley there are many SO_2 sensitive plant species, both natural and agricultural. Monitoring of the ambient air and the accumulation of pollutants in the atmosphere and environment has demonstrated potential hazardous levels of SO_2. Those substantial emissions, taken with the toxic concentrations of metals from the Anaconda smelter, have eliminated some ground cover to the extent that erosion has occurred. These problems are reflected by The Anaconda Company attempts to introduce resistant grasses and Ponderosa pine through experimental work. The presence of toxic chemicals and the reduction of native flora have degraded the environment in the Anaconda vicinity for wildlife and recreation.

3. The public detriment in the mere continuance of the present or slightly reduced levels of emissions from the Anaconda smelter includes the health and vegetative effects described above. That detriment alone would require the Department to recommend against granting the present variance request.

4. Weighing the public benefits, if any, and the public detriment from the granting of the variance request, the only recommendation the Department can make is to deny the variance request.

The Department has concluded that major water or solid waste pollution problems will not be created or significantly increased by meeting the substantial air pollution problem caused by sulfur emissions. To provide a reasonable time schedule for allocating the resources necessary to solve the air pollution problem, a compliance schedule should be adopted. The Department is prepared to consult with the Company as it moves to install the equipment necessary to meet state standards.

In recommending that the Montana State Board of Health deny the request for variance, the Department further proposes that a compliance schedule similar to the following be adopted:

A. Within 120 days the Company should submit, for approval by the Administrator of the Division of Environmental Sciences, a plan for compliance with Montana regulation 16-2.14(1)-S1470.

B. Within 6 months the Company should let contracts and issue purchase orders for emission control equipment including facilities and process modifications in accordance with that control plan.

C. Within 10 months the Company should initiate on-site construction, installation of emission control equipment, facilities and process changes.

E. Within 34 months the Company should acieve final compliance with Montana regulation 16-2.14(1)-S1470.

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62. "Air Quality Criteria for Sulfur Oxides," U.S. Dept. of Health, Education and Welfare, Public Health Service, Environmental Health Service, National Air Pollution Control Administration, Washington, D.C., April, 1970.

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APPENDIX

A

(18)

(f) Definition:

"Btu" means British thermal unit which is the heat required to raise the temperature of one pound of water through one Fahrenheit degree.

(2) Primary Non-Ferrous Smelters

(a) No person or persons shall cause, suffer, allow or permit to be discharged into the outdoor atmosphere from any copper, zinc or lead smelting operation or any slag treatment plant reduced sulfur in excess of the amount shown in the following table:

Total Feed of Sulfur, lb/hr	Allowable Sulfur Emission, lb/hr		
	Cu	Zn	Pb
1,000	100	100	100
5,000	500	394	348
10,000	1,000	704	593
20,000	2,000	1,270	1,000
40,000	4,000	2,310	1,000
60,000	6,000	3,210	1,000
80,000	8,000	4,120	1,000
100,000	10,000	5,000	1,000
Over 100,000	10,000	5,000	1,000

(b) For a total sulfur feed input between any two consecutive total sulfur feed inputs stated in the preceding table, maximum allowable emissions are shown in Figure 1 which follows this rule and by reference, is made a part of this rule. For the purposes hereof, total sulfur input shall be calculated as the aggregate sulfur content of all fuels and other feed materials whose products of combustion and gaseous byproducts pass through the stack or chimney.

(i) When two or more furnaces, sinter machines, sinter boxes, roasters, converters or other similar devices for converting copper, zinc or lead ores, concentrates, residues or slag to the metal or the oxide of the metal either wholly or in part are connected to a single stack, the combined sulfur input of all units connected to the stack shall be used to determine the allowable emission from the stack.

(ii) When a single furnace, sinter machine, sinter box, roaster, converter or other similar device for converting copper, zinc or lead ores, concentrates, residues, or slag to the metal or the oxide of the metal either sholly or in part is connected to two or more stacks, the allowable emission from all the stacks combined shall not exceed that allowable from the same unit connected to a single stack.

(c) The effective date of this section (2) for existing operations shall be June 30, 1973. For new operations, the effective date shall be June 30, 1970.

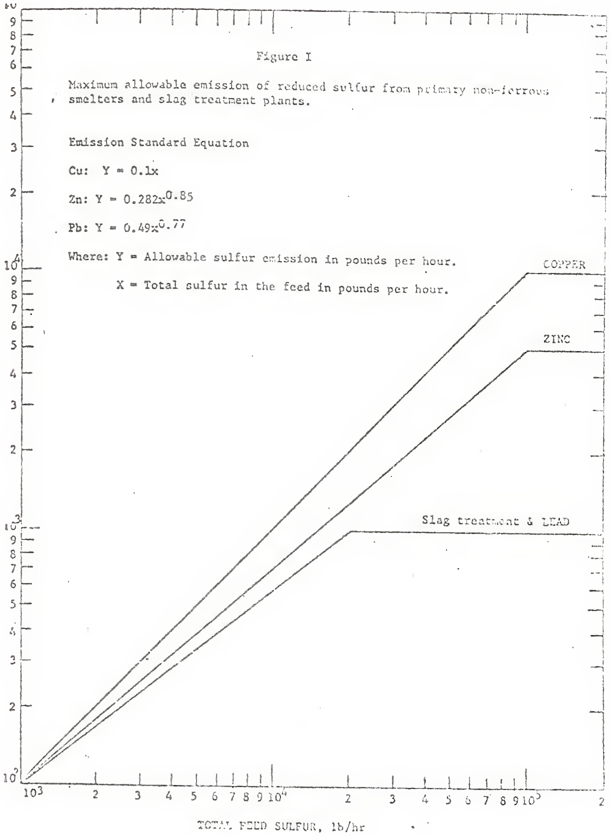


Figure I

Maximum allowable emission of reduced sulfur from primary non-ferrous smelters and slag treatment plants.

Emission Standard Equation

Cu: $Y = 0.1x$

Zn: $Y = 0.282x^{0.85}$

Pb: $Y = 0.49x^{0.77}$

Where: Y = Allowable sulfur emission in pounds per hour.

X = Total sulfur in the feed in pounds per hour.

16-2.14(1)-S14040 AMBIENT AIR QUALITY STANDARDS

(1) In accordance with section 69-3909, subsection 12 of the Clean Air Act of Montana, on May 27, 1967, the board adopted the Ambient Air Quality Standards shown below.

(2) Until additional pertinent information becomes available with respect to the effects of the substances listed below, the following air quality criteria shall apply in Montana.

Pollutants	Standards (Maximum permissible concentrations)
Sulfur dioxide[a]	0.02 ppm, maximum annual average. 0.10 ppm, 24-hour average, not to be exceeded over 1 percent of the days in any 3-month period. 0.25 ppm not to be exceeded for more than one hour in any 4 consecutive days
Reactive sulfur (sulfation[b])	0.25 milligrams sulfur trioxide per 100 square centimeters per day, maximum annual average 0.50 milligram sulfur trioxide per 100 square centimeters per day, maximum for any one-month period
Suspended sulfate[c]	4 micrograms per cubic meter of air, maximum allowable annual average 12 micrograms per cubic meter of air, not to be exceeded over 1 percent of the time
Sulfuric acid mist[d]	4 micrograms per cubic meter of air, maximum allowable annual average 12 micrograms per cubic meter of air, not to be exceeded over 1 percent of the time 30 micrograms per cubic meter of air, hourly average, not to be exceeded over 1 percent of the time
Hydrogen sulfide[e]	0.03 ppm, ½-hour average, not to be exceeded more than twice in any 5 consecutive days

Pollutants	Standards (Maximum permissible concentrations)
	0.05 ppm, ½-hour average not to be exceeded over twice a year
Total Suspended particulate[f]	75 micrograms per cubic meter of air, annual geometric mean 200 micrograms per cubic meter of air, not to be exceeded more than 1 percent of days a year
Settled particulate (Dustfall[g])	15 tons per square miles per month, 3-month average in residential areas 30 tons per square mile per month, 3-month average in heavy, industrial areas
Lead[h]	5.0 micrograms per cubic meter of air, 30-day average
Beryllium[i]	0.01 micrograms per cubic meter of air, 30-day average
Fluorides, total (as HF) in air[j]	1 part per billion parts of air, 24-hour average
Fluorides (asF) in forage[k] for animal consumption - dry weight basis	35 parts per million
Fluorides (gaseous)[l]	0.3 micrograms per square centimeter per 28 days

[a] Sulfur dioxide measured by West-Gaeke or conductometric method.

[b] Sulfation measured by lead-peroxide candle

[c] Suspended sulfate measured by high volume sampler - turbidmetric procedure

[d] Sulfuric acid mist- Air Pollution Control District, County of Los Angeles, APCD - Sulfuric acid 13-49

[e] Hydrogen sulfide measured by methylene blue method - lead acetate tape for screening and monitoring

[f] Suspended particulate measured by high-volume sampler

[g] Dustfall measured by container open to atmosphere

[h] Suspended lead measured by high-volume sampler - dithizone and/or spectrophotometric procedures

[i] Suspended beryllium measured by high-volume sampler - fluorometric and/or spectrophotometric method.

[j] Total fluoride measured by impingers - Winter-Willard distillation procedure (SPADNS color)

(16)

16-2.14(1)-S1460 VISIBLE AIR CONTAMINANTS, RESTRICTIONS

(1) Restriction of Existing Installations

No person shall cause, suffer, allow or permit emissions from any installations which are:

(a) Of a shade or density darker than that designated as No. 2 on the Ringelmann Chart, or

(b) Of such opacity as to obscure an observer's view to a degree greater than does smoke described in subsection (1)(a) of this regulation.

This section does not apply to existing incinerators or existing wood waste burners.

(2) Restriction of New Installations and All Incinerators

No person shall discharge into the atmosphere from any single source of emission whatsoever any air contaminant:

(a) Shade or density darker than that designated as No. 1 on the Ringelmann Chart, or

(b) Of such opacity as to obscure an observer's view to a degree greater than does smoke described in subsection (2)(a) of this regulation.

(3) The provisions of sections (1) and (2) of this rule shall not apply to emissions during the building of a new fire, cleaning of fires or soot blowing, the shade or density of which is less than No. 3 on the Ringelmann Smoke Chart or of such opacity as to obscure an observer's view to a degree greater than does smoke designated as No. 3 on the Ringelmann Smoke Chart for a period or periods aggregating no more than four minutes in any 60 minutes.

Where the presence of uncombined water is the only reason for failure of an emission to meet the requirements of sections (1) and (2) of this regulation, such sections shall not apply.

The provisions of section (1) of this regulation shall not apply to the following:

(a) Transfer of molten metals.

(b) Emissions from transfer ladles.

APPENDIX

B

CHAPTER 313

Enacted By

1967 LEGISLATIVE SESSION

Section 69-3904. Short Title.
69-3905. Declaration of Policy and Purpose.
69-3906. Definitions.
69-3907. Administration - State Board of Health.
69-3908. Air Pollution Control Advisory Council - members tenure - compensation - meetings - minutes - powers.
69-3909. Powers of Board.
69-3910. Classification and Reporting.
69-3911. Permits.
69-3912. Inspections.
69-3913. Emissions Prohibited.
69-3914. Enforcement.
69-3915. Emergency Procedure.
69-3916. Variances.
69-3917. Hearings and Judicial Review.
69-3918. Confidentiality of Records.
69-3919. Local Air Pollution Control Programs.
69-3920. State and Federal Aid.
69-3921. Penalties.
69-3922. Limitations.
69-3923. Classification of Property for Taxation.

69-3901 to 69-3903. Repealed.

69-3904. Short title. This act shall be known and may be cited as "the Clean Air Act of Montana."

69-3905. Declaration of policy and purpose. (1) It is hereby declared to be the public policy of this state and the purpose of this act to achieve and maintain such levels of air quality as will protect human health and safety, and to the greatest degree practicable, prevent injury to plant and animal life and property, foster the comfort and convenience of the people, promote the economic and social development of this state and facilitate the enjoyment of the natural attractions of this state.

(2) It is also declared that local and regional air pollution control programs are to be supported to the extent practicable as essential instruments for the securing and maintenance of appropriate levels of air quality.

(3) To these ends it is the purpose of this act to provide for a coordinated statewide program of air pollution prevention, abatement and control; for an

appropriate distribution of responsibilities among the state and local units of government; to facilitate cooperation across jurisdictional lines in dealing with problems of air pollution not confined within single jurisdictions; and to provide a framework within which all values may be balanced in the public interest.

69-3906. Definitions. As used in this act: (1) "Air contaminant" means dust, fumes, mist, smoke, other particulate matter, vapor, gas, odorous substances, or any combination thereof.

(2) "Air pollution" means the presence in the outdoor atmosphere of one or more air contaminants in such quantities and duration as is or tends to be injurious to human health or welfare, animal or plant life, or property, or would unreasonably interfere with the enjoyment of life or property, or conduct of business.

(3) "Emission" means a release into the outdoor atmosphere of air contaminants.

(4) "Person" means any individual, partnership, firm, association, municipality, public or private corporation, subdivision or agency of the state, trust, estate or any other legal entity.

(5) "Advisory council" means the air pollution control advisory council created by this act.

(6) "Director" means the director of air pollution control, a position created by this act.

(7) "Board" means the State Board of Health.

69-3907. Administration -- State Board of Health. The State Board of Health shall have responsibility for the administration of this act and shall appoint a director of air pollution control to assist the board in its administration hereunder.

(1) The director shall be a person with at least two (2) years' experience or training in the field of air pollution control, experienced in administrative work and procedures, and he must be a graduate in engineering, medicine, or in physical, chemical or biological sciences.

(2) The salary of the director will be set and paid by the board.

(3) The powers and duties of the director shall be established and prescribed by the board in its rules, regulations and standards.

(4) The director may delegate to any employee of the board such duties and functions as he deems necessary for the proper and efficient administration of this act, and the director shall have authority, with the approval of the board, to hire additional employees and to discharge same for cause.

69-3908. (1) There is hereby created an air pollution control advisory council. The advisory council shall consist of eleven (11) members as follows: The executive officer of the State Board of Health; and ten (10) members to be appointed by the governor as follows: a representative of labor; a representative of agriculture; a representative of the manufacturing industry; a representative of the fuel industry; a practicing physician licensed in Montana; a practicing veterinarian licensed in Montana; a practicing registered professional chemical or environmental engineer; a meterologist; a conservationist; and an urban planning consultant. The chairman shall be elected by the advisory council from among this number.

(2) Members are appointed by the governor with the advice and consent of the senate. The terms of members shall be four (4) years except that of the initially appointed members, two (2) shall serve for one (1) year, two (2) shall serve for two (2) years, three (3) shall serve for three (3) years and three (3) shall serve for four (4) years as designated by the governor at the time of making the appointment.

(3) No additional compensation shall be allowed any members of the advisory council for services rendered who are employed by the state government. The ten (10) members appointed by the governor to serve on the advisory council shall each be paid, in addition to actual travel expenses, twenty-five dollars ($25) per day for each day of actual services in the performance of their duties, and all members of the advisory council shall be reimbursed for travel and other necessary expenses incurred in their official duties as members of the advisory council.

All expenses of members who are otherwise in the employ of the state government shall be paid from the appropriation to their respective agencies. The expenses and per diem of the members who are appointed by the governor shall be paid from funds made available to the State Board of Health.

(4) The advisory council shall hold at least two (2) regular meetings each calendar year and shall keep a summary record of its proceedings which shall be open to the public for inspection. Special meetings may be called by the chairman and must be called by him upon receipt of a written request signed by two (2) or more members of the advisory council. Notice of the time and place for all meetings shall be given in advance to each member of the advisory council by the secretary. A majority of the members of the advisory council shall constitute a quorum.

(5) The secretary of the advisory council shall be a member of the staff of the State Board of Health, designated by the executive officer of the board. The secretary shall keep all records of the meetings, and actions taken by, the council. He shall keep the advisory council advised as to actions taken by persons in response to recommendations and orders issued under authority of this act and shall perform other duties as determined by the advisory council, not inconsistent with rules, regulations, policies adopted by authority of this act or specific authority otherwise given the advisory council.

(6) The advisory council may consider standards, rules, and regulations as provided in Section 69-3913 of this act and any other matter related to the purposes of the act, which may be submitted to it by the board. It may make recommendations to the board on its own initiative concerning the administration of this act.

69-3909. Powers of board. In addition to any other powers conferred on it by law the board shall:

(1) Adopt, amend, and repeal rules implementing and consistent with the provisions of this act.

(2) Hold hearings relating to any aspect of or matter in the administration of this act, at any place or places designated by the board. The board may designate the

director as the hearing officer at any hearing set by the board and authorize him to make rulings on evidence and conduct the hearing. The board or the director as hearing officer may compel the attendance of witnesses and the production of evidence at hearings. The board shall designate an attorney to assist in conducting hearings and shall appoint a reporter who shall be present at all hearings and take full stenographic notes of all proceedings thereat, transcripts of which will be available to the public at cost.

(3) Issue such orders as may be necesary to effectuate the purposes of this act and enforce them by all appropriate administrative and judicial proceedings.

(4) Require access to records relating to emissions.

(5) Secure necessary scientific, technical, administrative, and operational service, including laboratory facilities, by contract or otherwise.

(6) Prepare and develop a comprehensive plan or plans for the prevention, abatement, and control of air pollution in this state.

(7) Encourage voluntary cooperation by persons and affected groups to achieve the purposes of this act.

(8) Encourage local units of government to handle air pollution problems within their respective jurisdictions on a cooperative basis, and to provide technical and consultative assistance therefor. If local programs are financed with public funds, the board may contract with the local government to share the cost of the program. However, the state share may not exceed thirty percent (30%) of the total cost.

(9) Encourage and conduct studies, investigations, and research relating to air contamination and air pollution and their causes, effects, preventions, abatement and control.

(10) Determine by means of field studies and sampling the degree of air contamination and air pollution in the state and the several parts thereof.

(11) Make a continuing study of the effects of the emission of air contaminants from motor vehicles on the quality of the outdoor atmosphere of this state and the several parts thereof, and make recommendations to appropriate public and private bodies with respect thereto.

(12) Establish ambient air quality standards for the state as a whole within ninety (90) days of passage and approval of this act.

(13) Collect and disseminate information and conduct educational and training programs relating to air contamination and air pollution.

(14) Advise, consult, contract, and cooperate with other agencies of the state, local governments, industries, other states, interstate and interlocal agencies, the United States, and any interested persons or groups.

(15) Consult, upon request, with any person proposing to construct, install or otherwise acquire an air contaminant source or device or system for the control thereof, concerning the efficacy of such device or system, or the air pollution problems which may be related to the source, device, or system. Nothing in any such consultation shall be construed to relieve any person from compliance with this act, rules in force pursuant thereto, and any other provision of law.

(16) Accept, receive, and administer grants or other funds or gifts from public or private agencies, including the United States, for the purpose of carrying out any of the functions of this act. Funds received by the board pursuant to this section shall be deposited in the state treasury to the account of the board.

69-3910. Classification and reporting. (1) The board may classify air contaminant sources which in its judgment may cause or contribute to air pollution according to levels and types of emissions and other characteristics which relate to air pollution, and may require reporting for any such class or classes. Such classifications shall be made with special reference to effects on health, economic and social factors, and physical effects on property, and may be applied to the state as a whole or to any designated area. (2) Any person operating or responsible for the operation of air contaminant sources of any class for which the rules of the board may require reporting shall make reports containing such information as may be required concerning location, size and height of contaminant outlets, processes employed, fuels used, and the nature and time periods or duration of emissions, and any other matter relevant to air pollution which is available or reasonably capable of being assembled.

69-3911. Permits. (1) The board may, by rule or regulations, prohibit the installation, alteration, or use of any machine, equipment, device or other article which it finds may cause or contribute to air pollution or which is intended primarily to prevent or control the emission of air pollutants, unless a permit therefor has been obtained from it.

(2) The board may require that applications for such permits shall be accompanied by plans, specifications, and such other information as it deems necessary.

(3) The board shall provide for the issuance, suspension, revocation, and renewal of any permits which it may require pursuant to this section.

(4) If a permit is required, the board must decide within ninety (90) days after receiving application therefor, whether or not the permit will issue. If no decision is rendered within that time, permission shall be deemed to have been granted.

69-3912. Inspections. (1) Any duly authorized officer, employee, or representative of the board may enter and inspect, at any reasonable time, any property, premises, or place, except a private residence, on or at which an air contaminant source is located or is being constructed or installed for the purpose of ascertaining the state of compliance with this act and rules in force pursuant thereto.

(2) No person shall refuse entry or access to any authorized representative of the board who requests entry for purposes of inspection, and who presents appropriate credentials. No person shall obstruct, hamper, or interfere with any such inspection.

(3) At his request, the owner or operator of the premises shall receive a report setting forth all facts found which relate to compliance status.

69-3913. Emissions prohibited. (1) The board may establish the limitations of the levels, concentrations, or quantities of emission of various pollutants from any source necessary to prevent, abate or control air pollution. Except as otherwise provided in or pursuant to this section, such levels, concentrations, or quantities shall be controlling and no emission in excess thereof shall be lawful.

(2) In any area where the concentration of air pollution sources or of population, or where the nature of the economy of or land and its uses so require, the board may fix more stringent requirements governing the emission of air pollutants than those in effect pursuant to Subsection (1) of this section.

(3) The board may by rule use any widely recognized measuring system for measuring emission of air contaminants.

(4) Should federal minimum standards of air pollution be set by federal law, the board may, if necessary in some localities of this state, set more stringent standards by rule or regulation.

69-3914. Enforcement. (1) Whenever the board has reason to believe that a violation of any provision of this act or rule made pursuant thereto has occurred, it may cause written notice to be served upon the alleged violator or violators. The notice shall specify the provision of this act or rule alleged to be violated, and the facts alleged to constitute a violation thereof, and may include an order to take necessary corrective action within a reasonable period of time stated in the order. Any such order shall become final unless, no later than thirty (30) days after the date the notice is received, the person or persons named therein request in writing a hearing before the board. Upon receipt of such a request, the board shall hold a hearing.

(2) If, after a hearing held pursuant to Subsection (1) of this section, the board finds that a violation or violations have occurred, it shall either affirm or modify any order previously issued, or issue an appropriate order or orders for the prevention, abatement, or control of the emissions involved or for the taking of such other corrective action as it may deem appropriate. If, after hearing on an order contained in a notice the board finds that no violation is occurring, it shall rescind the order. Any order issued as part of a notice or after hearing may prescribe the date or dates by which the violation or violations shall cease and may prescribe time limits for particular action in preventing, abating, or controlling the emissions.

(3) In lieu of issuing the order provided for in Subsection (1) of this section, the board may either:

(a) Require that the alleged violator or violators appear before it for a hearing at a time and place specified in the notice, and answer the charges complained of; or

(b) Initiate action pursuant to Section 69-3921 of this act.

(4) Nothing in this act shall prevent the board from making efforts to obtain voluntary compliance through warning, conference, or any other appropriate means.

(5) In connection with any hearing held pursuant to this section, the board may, and upon application by any party shall, compel the attendance of witnesses and the production of evidence on behalf of all parties.

69-3915. Emergency procedure. (1) Any other provisions of law to the contrary notwithstanding, if the director finds that a generalized condition of air pollution exists and that it creates an emergency requiring immediate action to protect human health or safety, the director shall order persons causing or contributing to the air pollution to reduce or discontinue immediately the emission of air contaminants. Upon issuance of any such order, the director shall fix a place and time, not later than twenty-four (24) hours thereafter, for a hearing to be held before the board. Not more than twenty-four (24) hours after the commencement of such hearing, and without adjournment thereof, the board shall affirm, modify, or set aside the order of the director.

(2) In the absence of any such generalized condition as that referred to in Subsection (1) of this section, if the director finds that emissions from the operation of one or more air contaminant sources is causing imminent danger to human health or safety, he may order the person or persons responsible for the operation or operations in question to reduce or discontinue emissions immediately, without regard for the provision of Section 69-3914 of this act. In such event, the requirements for hearing, and affirmance, modification, or setting aside of orders set forth in Subsection (1) of this section shall apply.

(3) Nothing in this section shall be construed to limit any power which the governor or any other officer may have to declare an emergency and act on the basis of such declaration, whether such power is conferred by statute or constitutional provisions or inheres in the office.

69-3916. Variances. (1) Any person who owns or is in control of any plant, building, structure, process or equipment may apply to the board for an exemption or partial exemption from rules or regulations governing the quality, nature, duration, or extent of emissions of air pollutants. The application shall be accompanied by such information and data as the board may require. The board may grant such exemption or partial exemption if it finds that:

(a) The emissions occurring or proposed to occur do not constitute a danger to public health or safety; and

(b) Compliance with the rules or regulations from which exemption if sought would produce hardship without equal or greater benefits to the public.

(2) No exemption or partial exemption shall be granted pursuant to this section except after public hearing on due notice and until the board has considered the relative interests of the applicant, other owners or property likely to be affected by the emissions, and the general public.

(3) No exemption or partial exemption pursuant to this section shall be granted for a period to exceed one (1) year, but any such exemption or partial exemption may be renewed for like periods if no complaint is made to the board on account thereof or if, such complaint having been made and duly considered at a public hearing held by the board on due notice, the board finds that renewal is justified. No renewal shall be granted except on application therefor. Any such application shall be made at least sixty (60) days prior to the expiration of the exemption or partial exemption. Immediately prior to application for renewal the applicant shall give public notice of such application in accordance with rules and regulations of the board. Any renewal pursuant to this subsection shall be on the same grounds and subject to the same limitations and require-

ments as provided in Subsection (a) of this section.

(4) An exemption, partial exemption or renewal thereof shall not be a right of the applicant or holder thereof but shall be in the discretion of the board. However, any person adversely affected by an exemption, partial exemption or renewal granted by the board may obtain judicial review thereof as provided by Section 69-3917 of this act.

(5) Nothing in this section and no exemption, partial exemption or renewal granted pursuant hereto shall be construed to prevent or limit the application of the emergency provisions and procedures of Section 69-3915 of this act to any person or his property.

69-3917. Hearings and judicial review. (1) No rule and no amendment or repeal thereof shall take effect except after public hearing on due notice, and after the advisory council has been afforded not less than thirty (30) days prior to publication of the proposed text to comment thereon. Such notice shall be given by public advertisement not less than twenty (20) or more than thirty (30) days prior to the date set for such hearing.

(2) Nothing in this section shall be construed to require a hearing prior to the issuance of an emergency order pursuant to Section 69-3915 of this act.

(3) Any person aggrieved by any order of the board or local control authority may apply for rehearing upon one or more of the following grounds, and upon no other grounds:

(a) The board or local control authority acted without or in excess of its powers;

(b) The order was procured by fraud;

(c) The order is contrary to the evidence;

(d) The applicant has discovered new evidence, material to him, which he could not, with reasonable diligence, have discovered and produced at the hearing;

(e) Competent evidence was excluded to the prejudice of the applicant.

The petition must be in such form and filed in such time as the board shall prescribe.

(4) (a) Within thirty (30) days after the application for rehearing is denied, or, if the application is granted, within thirty (30) days after the decision on the rehearing, any party aggrieved thereby may appeal to the district court of any judicial district of the state which is the situs of property affected by the order.

(b) The appeal shall be taken by serving a written notice of appeal upon the executive officer of the board, which service shall be made by the delivery of a copy of the notice to such officer, and by filing the original with the clerk of the court to which the appeal is taken. Immediately upon service upon the board, the board shall certify to the district court the entire record and proceedings, indluding all testimony and evidence taken by the board. Immediately upon receiving the certified record, the district court shall fix a day for filing of briefs and hearing arguments on the cause, and shall cause a notice of the same to be served upon the board and the appellant.

(c) The court shall hear and decide the cause upon the record of the board. The court shall determine whether or not the board regularly pursued its authority, whether or not the findings of the board were supported by substantial competent evidence and whether or not the board made errors of law prejudicial to the appellant.

(5) Either the board or the person aggrieved may appeal from the decision of the district court to the supreme court. The proceedings before the supreme court shall be limited to a review of the record of the hearing before the board and of the district court's review of that record.

69-3918. Confidentiality of records. (1) Any records or other information concerning air contaminant sources which are furnished to or obtained by the board, and which, as certified by the owner or operator, relate to production or sales figures or to processes or production unique to the owner or operator or which would tend to affect adversely his competitive position, shall be only for the confidential use of the board in the administration of this act, unless the owner shall expressly agree to their publication or availability to the general public.

(2) Nothing contained in this section shall be construed to prevent the use of such records or information by the board in compiling or publishing analyses or summaries relating to the general condition of the outdoor atmosphere, provided that such analyses or summaries do not identify any owner or operator or reveal any information made otherwise confidential by the provisions of this section.

69-3919. Local air pollution control programs. (1) Any municipality or county may establish a local air pollution control program upon being petitioned by fifteen percent (15%) of the qualified electors within its jurisdiction, and may thereafter administer within its jurisdiction said air pollution control program which:

(a) Provides by ordinance or local law for requirements compatible with, more stringent, or more extensive than those imposed by Sections 69-3913, 69-3915 and 69-3916 of this act and rules issued thereunder;

(b) Provides for the enforcement of such requirements by appropriate administrative and judicial process;

(c) Provides for administrative organization, staff, financial and other resources necessary to effectively and efficiently carry out its program;

(d) Provided that such program shall be consistent with the intent and purposes of this act and is approved by the board after a public hearing conducted according to the provisions of Section 69-3909 of this act.

(2) If the board finds that the location, character, or extent or particular concentrations of population, or air contaminant sources, or geographic, topographic, or meteorological considerations, or any combinations of any of the foregoing, are such as to make impracticable the maintenance of appropriate levels

of air quality without an areawide air pollution control program, the board may determine the boundaries within which such program is necessary and require it as the only acceptable alternative to direct state administration.

(3) (a) If the board has reason to believe that an air pollution control program in force pursuant to this section is inadequate to prevent and control air pollution in the jurisdiction to which such program relates, or that the program is being administered in a manner inconsistent with the requirements of this act, the board shall, on due notice, conduct a hearing on the matter.

(b) If, after the hearing, the board determines that the program is inadequate to prevent and control air pollution in the jurisdiction to which it relates, or that it is not accomplishing the purposes of this act, it shall require that necessary corrective measures be taken within a reasonable time, not to exceed sixty (60) days.

(c) If the jurisdiction fails to take such measures within the time required, the board shall administer within such jurisdiction all of the provisions of this act. The board's control program shall supersede all municipal or county air pollution laws, regulations, ordinances, and requirements in the affected jurisdiction. The cost of such a program shall be a charge on the municipality or county.

(4) If the board finds that the control of a particular class of air contaminant source because of its complexity or magnitude is beyond the reasonable capability of the local jurisdiction or may be more efficiently and economically performed at the state level, it may assume and retain control over that class of air contaminant source. No charge shall be assessed against the jurisdiction therefor. Findings made pursuant to this subsection may be either on the basis of the nature of the sources involved or on the basis of their relationship to the size of the communities in which they are located.

(5) Any jurisdiction in which the board administers its air pollution control program pursuant to Subsection (3) of this section may with the approval of the board establish or resume an air pollution control program which meets the

requirements of Subsection (1) of this section.

(6) Any municipality or county may administer all or part of its air pollution control program in cooperation with one (1) or more municipalities or counties of this state or of other states.

(7) Nothing in this act shall be construed to supersede or oust the jurisdiction of any local air pollution control program in operation on the effective date of this act, provided that within two (2) years from such date any such program meets all requirements of this act for a local air pollution control program.

69-3920. State and federal aid. (1) Any local air pollution control program meeting the requirements of this act and rules made pursuant thereto shall be eligible for state aid in an amount equal to thirty percent (30%) of the locally funded annual operating cost thereof.

(2) Subdivisions of the state may make application for, receive, administer, and expend any federal aid for the control of air pollution or the development and administration of programs related to air pollution control, provided that any such application is first submitted to and approved by the board. The board shall approve any such application if it is consistent with this act and any other applicable requirements of law.

69-3921. Penalties. (1) Any person who violates any provision of this act, or any rule in force thereunder or any order made pursuant thereto, other than Section 69-3918, shall be guilty of an offense and subject on account thereof to a fine not to exceed one thousand dollars ($1000). Each day of violation shall constitute a separate offense.

(2) Any person who willfully violates Section 69-3918 of this act shall be guilty of an offense and subject on account thereof to a fine not to exceed one thousand dollars ($1000).

(3) Action pursuant to Subsections (1) and (2) of this section shall not be a bar to enforcement of this act, or of rules or orders made pursuant thereto, by injunction or other appropriate remedy. The board may institute and maintain

in the name of the state any and all such enforcement proceedings.

(4) Nothing in this act shall be construed to abridge, limit, impair, create, enlarge, or otherwise affect substantively or procedurally the right of any person to damage or other relief on account of injury to persons or property and to maintain any action or other appropriate proceeding therefor.

(5) All fines collected shall be deposited to the state general fund.

69-3922. Limitations. Nothing in this act shall be construed to:

(1) Grant to the board any jurisdiction or authority with respect to air contamination existing solely within commercial and industrial plants, works, or shops.

(2) Affect the relations between employers and employees with respect to or arising out of any condition of air contamination or air pollution.

(3) Supersede or limit the applicability of any law or ordinance relating to sanitation, industrial health, or safety.

69-3923. Classification of property for taxation. (1) Facilities, machinery or equipment, attached or unattached to real property, utilized to reduce, eliminate, control or prevent air pollution, shall be classified as Class Seven (7) for the purpose of taxation under the provisions of Section 84-301.

(2) The decision, whether the facilities, machinery or equipment are utilized to reduce, eliminate, control or prevent air pollution, shall be made by the director and approved by the State Board of Equalization.

69-3924. Severability. It is the intent of the legislative assembly that if a part of this act is invalid, all valid parts that are severable from the invalid part remain in effect. If a part of this act is invalid in one or more of its applications, the part remains in effect in all valid applications that are severable from the invalid applications.

69-3925. Sections 69-3901, 69-3902, and 69-3903, R.C.M., 1947, are hereby repealed.

APPENDIX

C

BEFORE THE DEPARTMENT OF HEALTH

AND ENVIRONMENTAL SCIENCES

OF THE STATE OF MONTANA

In the matter of the application of the Primary Metals Division of The Anaconda Company, a Montana Corporation, for a variance from the sulphur oxide emission regulations applicable to the operation of its copper smelter at Anaconda, Montana	)	PETITION FOR VARIANCE

In accordance with the procedural rules under Sub-Chapter 1 of Chapter 2 of the Department's Rules, the Primary Metals Division of The Anaconda Company (Petitioner) respectfully requests a variance and exemption from the sulphur oxide emission regulations pursuant to provisions of the Montana Clean Air Act as the same pertains to the operation of Petitioner's copper smelter at Anaconda, Montana.

1. The person authorized to receive service of notices for Petitioner is William P. Mufich, Counsel for Petitioner, whose address is 600 Hennessy Building, Butte, Montana 59701, and whose telephone number is (406) 723-4311.

2. Petitioner is an operating division of The Anaconda Company, a Montana corporation. Division officers include R. C. Weed, president; A. J. McDonell, executive vice president; M. K. Hannifan, vice president for operations; R. C. Cereghini, vice president for finance; and C. J. Hansen, vice president and chief counsel; headquarters of the Division is located at Kolb Road and Interstate 10, Tucson, Arizona and the mailing address is P.O. Box 11309, Tucson, Arizona 85734. The person in charge

of the smelter is Emil S. Kramlick, manager of the Anaconda Reduction Department, whose mailing address is The Anaconda Company, Anaconda, Montana 59711.

3. The type of activity involved is the operation of a pyrometallurgical copper smelter and it is located east of the City of Anaconda, Montana.

4. Petitioner's smelter treats copper concentrates and precipitates to produce anode copper. Feed material is dried and charged to reverberatory furnaces. Silica and lime flux is added to the feed in the reverberatories to accomplish smelting. These furnaces are fired by natural gas and operate at approximately 2000°F. The primary product from this reverbatory operation is molten copper matte. By-products include molten slag which is granulated and stored as solid waste and off-gases that contain sulphur dioxide, particulates, metal vapors and combustion products. All off-gases are routed through a common exhaust system. Copper matte is charged into converters where the remaining sulphur is oxidized and driven off into the main flue system. Blister copper which results from the converter operation is treated in a refining furnace and cast into anodes. Slag which is generated in converters returns to the reverberatories.

5. The regulation pertinent to this application is 16-2.14(1)-51470(2) of the Montana Administrative Code relating to sulphur oxide emissions from primary non-ferrous smelters.

6. Compliance with the designated regulation is unreasonable because it is not possible for Petitioner, under the

present configuration of its smelter plant and control equipment, to restrict sulphur emissions to 10 percent of total feed as required by the regulation. Petitioner is now completing an environmental control program at the smelter for which the expenditure has been approximately $20 million. This includes construction of a 600 tons-per-day double-contact/double-absorption sulphuric acid plant for the treatment of converter gases, and the installation of a new flue and water-cooled hood system to exhaust converter gases. The hood system will provide a significant reduction in low-level fugitive emissions from the converter roof. When the acid plant, which is now being phased into operation, is at full capacity, the total sulphur retention will be 32 percent at the design production rate of 35 million pounds of copper per month. Retention of 90 percent, as required by the regulation, is not possible because only the converter gases are of sufficient strength for treatment in an acid plant, and only about 60 percent of the sulphur in the total plant feed reports to the converter. Gases from the reverberatories or other sources are not amenable to treatment in an acid plant. Since no facilities are available to Petitioner for the treatment or control of those gases by the compliance date or during the period of the requested variance, it is not reasonable to require Petitioner's compliance with the regulation.

7. The variance is requested for a period of one year. Petitioner seeks the variance so that it can continue the operation of its smelter during that period and also to provide time within which to continue the design and construction of

additional air quality control devices and systems at the smelter.

8. If compliance with the regulation were required on the effective date, Petitioner would be unable to comply with emission limitations and operation of the smelter would have to be disrupted.

9. As noted in prior paragraph 6, Petitioner's smelter will achieve a sulphur retention of 32 percent when the acid plant becomes fully operational. It is expected that this will be accomplished during July of 1973. Petitioner also has started construction of a hydrometallurgical plant which will utilize its Arbiter process and be operated as a part of Petitioner's smelter complex at Anaconda, Montana. This facility will produce 100 tons per day of cathode copper from sulphide concentrates but it will not generate any sulphur oxides. The Arbiter plant also will selectively accomplish a reduction in sulphur feed to the existing smelter and an equal reduction of sulphur emissions to the atmosphere. When the Arbiter plant becomes operational, in late 1974, approximately 50 percent of the total sulphur feed to the smelting complex will be retained. The cost of the Arbiter plant will exceed $25 million. Additionally, Petitioner has under design for its smelter the installation of a fluo-solids roaster to replace the drying furnace and the installation of an electric furnace to replace the reverberatory furnaces. The estimated cost of these further environmental controls is approximately $33 million. Completion of these installations cannot be achieved until late in 1975. At that time, the gas and particulate loadings in the exhaust will be materially different than that

which exists now. Petitioner believes that following completion of this control program, a reasonable period of operation should be allowed to determine the results achieved by these installations upon the consist and retention of emissions. It is difficult to determine at this date what further control devices or procedures may be available and operationally feasible after construction and testing of the program Petitioner now has under way. While the electric furnace installation could enable some further retention through treatment of gases by additional sulphuric acid plants, this may well result in severe adverse impacts upon the environment. Through use in its mining operations and potential sale, Petitioner hopes to be able to dispose of its scheduled production of 600 tons per day of sulphuric acid from its present acid plant. However, if additional acid production were required, it could not be disposed of by sale under present market conditions for sulphuric acid. This additional acid would have to be neutralized, creating significant solid waste disposal problems, requiring undue consumption of other resources, and adding substantially to the cost of operation.

10. The advantages to the residents of Montana resulting from the granting of the requested variance would be, primarily, the uninterrupted operation of the smelter and the continuation of the current construction program. Petitioner's plant constitutes the major source of employment in the Anaconda area and any disruption of smelter operations would impose severe economic hardships upon the residents of the community. Petitioner directly employs more than 1400 persons in its operations at Anaconda, with

a total annual payroll of approximately $20 million. It is the main source of tax revenue and the principal purchaser of gas, power, freight and supplies in the area. Expenditures for environmental controls alone will amount to $53 million through 1975 and construction of the Arbiter plant will increase that total to at least $78 million. The smelter produces 35 million pounds of copper per month and the loss of that supply would cause extreme difficulties for numerous manufacturing and fabricating firms who rely upon Petitioner to furnish essential amounts of copper. If operation of the smelter had to be discontinued for any period of duration, Petitioner's mining, refining and railroading operations in Butte and Great Falls, Montana also would have to be drastically curtailed or even closed because the smelter is essential to both the mining and refining operations. More than 4500 citizens of Montana are employed in these other operations and the impact of the loss of these jobs would be extremely detrimental to the economy of the entire State. A substantial number of persons now working in construction projects or for suppliers to Petitioner also would be adversely affected.

11. The operation of Petitioner's smelter under the requested variance would not constitute a nuisance. Evaluation of measurements of SO_2 concentrations over the past seven months demonstrates that Petitioner's control program will be entirely adequate to meet the national ambient air quality standards established by the Environmental Protection Agency.

12. Petitioner has no knowledge of any case pending in any Montana court, civil or criminal, relating to the identical

equipment or process involved in this application. Petitioner is the plaintiff in an action entitled "The Anaconda Company vs. Ruckelshaus, et al" filed in Federal District Court in Denver, Colorado, by which Petitioner contested the promulgation of certain proposed emission standards applicable to Petitioner's smelter by the Environmental Protection Agency. After a ruling favorable to Petitioner, the Government appealed and the matter is now pending before the U.S. Court of Appeals for the Tenth Circuit at Denver and is designated as Cause No. 72-1272.

13. Petitioner has obtained a construction permit from the Department for the acid plant erected in connection with its control program.

Petitioner respectfully submits that in view of the facts presented in this application, the variance sought herein should be granted.

THE ANACONDA COMPANY
Primary Metals Division

By CJ Hansen
C. J. Hansen
Vice President and
Chief Counsel

APPENDIX

D

6. ECONOMIC ANALYSIS

6.1 COPPER EXTRACTION

6.1.1 Copper Industry Economic Profile

Industry Structure

The primary copper extraction industry is composed of companies primarily engaged in the mining, beneficiation, smelting, and refining of copper metal and fabrication of copper metal products. In addition, the industry produces other marketable metals and minerals from by-product materials processed in the winning of copper from ores. These include lead, zinc, silver, molybdenum, tellurium, gold, selenium, arsenic, cadmium, and titanium.

Table 6-1 is an analysis of each company's contribution in mining, smelting, refining, and marketing of refined copper metal.

The leading marketers of domestic refined copper, according to Table 6-1 are Kennecott, American Smelting and Refining (ASARCO), and Phelps Dodge, in order of sales. These three firms account for 61 percent of the primary copper industry output. With the addition of American Metal Climax and Anaconda, five firms market approximately 85 percent of the nation's refinery production.

A tabulation of individual smelters and refinery plants is presented in Table 6-2. Generally, the integrated companies have a refinery located nearby a smelter. The exceptions to this rule are the ASARCO smelters in the Southwest, Phelps Dodge's Douglas smelter, and Kennecott's McGill and Hayden smelters.

Of the five earlier mentioned large firms, Kennecott is completely integrated from the mine through the refinery; that is, it controls all stages of production for its output. Phelps Dodge and Anaconda are extensively integrated in that wholly-owned mine output consists large proportion of its output. Phelps Dodge has had a large share in domestic refining although in 1972 this will change as Newmont Mining starts its new refinery in San Manuel, Arizona. ASARCO plays the role of custom smelter and refiner as it mines domestically only some 18 percent of its final production. ASARCO, American Metal Climax, and Cerro process copper scrap into refined copper.

TABLE 6-1 PRODUCTION AND SALES OF REFINED COPPER FOR THE LEADING CORPORATIONS IN THE UNITED STATES FOR 1971 (SHORT TONS OF COPPER)

Company	Domestic Mine Production	Estimated Smelter Production	Estimated Refinery Production	Estimated Domestic Sales of Refined Copper	Approximate Market Share, As % of Sales	Remarks
ASARCO	66,200	300,000	406,500(1)	406,500	20.2	
American Metal Climax	----	----	182,000(1)	208,000	10.3	
Anaconda	182,000	138,000	210,000(2)	249,000	12.4	
Bagdad Copper Co.	19,800	----	----	----	----	Sells Concentrates to ASARCO
Cerro Corp.	----	----	49,000(1)	49,000	2.4	
Cities Service	49,000	18,000	----	44,000	2.2	
Duval Corp. (Pennzoil Corp.)	124,500	----	----	----	----	Sells Concentrates to ASACRO
Inspiration Consolidated Copper Co.	56,000	96,300(5)	57,000	----	----	Refined Output Sold by Anaconda
Kennecott Consolidated Copper Corp.	456,000	470,000	456,000	488,000	24.3	
Magma Copper Co. (Newmont Mining Corp.)	101,000	102,000	----(3)	101,000	5.0	Refined Output Sold by International Minerals & Metals Corp.
Phelps Dodge	281,200	344,600	526,600	340,000	16.9	
Pima Mining Co.	68,000	----	----(4)	68,000	3.4	Refined Output Sold by Ametalco, Ltd.
White Pine Copper Co. (Copper Range)	58,600	58,000	58,000	58,000	2.9	
Other U.S. Mines	58,100	----	----	----	----	Concentrates Sold to ASARCO, Phelps Dodge
TOTALS	1,520,400	1,526,900	1,945,100	2,011,500		

(1) Secondary scrap and possible foreign blister is included.
(2) Includes Canadian mine production as well as purchased materials.
(3) Refined by Phelps Dodge, In 1972, Magma will start own new refinery.
(4) Smelted and refined by Phelps Dodge.
(5) Smelts Anaconda's Arizona mine output.

SOURCES: Annual Corporate Reports, Moody's Industrial Surveys, American Bureau of Metal Statistics, Private Communication with Individual Companies

TABLE 6 -2 SMELTER AND REFINERY(1) STATISTICS--LOCATION, CAPACITY, AND OWNERSHIP

Company/Division	Smelter Location	Smelter Capacity Furnace Charge (TPY)	Associated Refinery for Processing Associated Blister, Anodes	Electrolytic Refinery Capacity, Tons/Year Copper
The Anaconda Company	Anaconda, Mont.	1,000,000	Great Falls, Mont.	190,000
ASARCO	Tacoma, Wash.	600,000	Tacoma, Wash.	156,000
	Hayden, Ariz.	960,000	Atlantic Coast(2)	
	El Paso, Texas	576,000	Atlantic Coast(2)	
Cities Service Corp.	Copper Hill, Tenn.	90,000	----	---
Inspiration Consolidated Copper	Miami, Ariz.	450,000	Inspiration, Ariz(3)	70,000
Kennecott Copper Corp:				
Nevada Mines Division	McGill, Nev.	400,000	Anne Arundel, Md.	276,000
Chino Mines Division	Hurley, N. M.	400,000	Hurley (Fire-Refined)	103,000
Ray Mires Division	Hayden, ARiz.	420,000	Anne Arundel, Md.	(See McGill)
Utah Copper Division	Salt Lake City (Garfield)	1,000,000	Magna, Utah	186,000
Phelps Dodge:				
Douglas Smelter	Douglas, Ariz.	875,000	Custom Smelter	---
Morenci Branch	Morenci, Ariz.	900,000	El Paso, Texas	420,000(4)
New Cornelia Branch	Ajo, Ariz.	300,000	El Paso, Texas	(See Morenci)
Newmont Mining Corp.	San Manuel (Magma Copper)	670,000(5)	San Manuel, Ariz.	200,000(5)
Copper Range	White Pine, Michigan	90,000(6)	White Pine, Michigan	90,000(7)

Footnotes - See next page.

FOOTNOTES - Table 6-2

(1)Three refineries process foreign blister reclaimed scrap and domestic overflows (Western U.S. Blister)--Laurel, N. Y. (Phelps Dodge); 74,000 TPY; Carteret, N. J. (U.S. Metals Refining, Amax); 175,000 TPY Electrolytic; 85,000 TPY Fire-Refined; St. Louis, Mo. (Cerro); 44,000 TPY Electrolytic.

(2)ASARCO has 2 refineries on Atlantic Coast--Perth Amboy, N. J.; 168,000 TPY and Baltimore, Md.; 318,000 TPY.

(3)Smelter overflow goes to International Smelting & Refining, Raritan, N. J.; 150,000 TPY.

(4)Electrolytic capacity; Phelps Dodge also has a 23,000 TPY fire-refined refinery at El Paso, Texas for treating Morenci output.

(5)A third reverb furnace (267,000 TPY) completed in 1971. Refinery to be on-stream in 1972.

(6)Measured as copper product.

(7)Lake refined.

SOURCE: American Bureau of Metal Statistics, Arthur D. Little, EPA.

For some firms the degree of vertical integration of production activities extends beyond refining into the fabrication of metal products. Phelps Dodge, Anaconda, Cerro, and Kennecott are important in the fabrication of wire, plate, rod, and sheet products. These four firms collectively account for over 50 percent of sales by wire mills and brass mills.

Production

Finished, unalloyed copper (refined) is produced in three grades--electrolytic, fire-refined, and Lake. Electrolytic copper is refined by electrolytic deposition, remelted, and cast into commercial shapes. Fire-refined copper is refined by oxidation in a furnace forming a slag containing most of the impurities which is removed, followed by reduction to eliminate most of the oxygen linked with copper as oxide. Lake copper is copper native only in the upper Michigan peninsula. Refined copper is produced from both ores and recovered copper scrap.

Alloyed copper is produced in the form of many types of brasses and bronzes. Old scrap is melted down and cast as various types of alloys. Brass and bronze foundries and brass mills are the producers of alloyed copper.

An analysis of production of the types of refined and alloyed copper for the years of 1962 through 1971 is presented in Table 6-3. Refining of domestic mine output and foreign material (ores and blister) is categorized into electrolytic, fire-refined, and Lake refined. Refined copper from copper scrap is shown separately for primary refineries and secondary smelters. Lastly alloy production is shown under the heading of non-refined secondary recovery. Scrap supplies provide about 40 to 45 percent of new copper production on an annual basis.

A balance sheet for flow of refined copper production is presented in Table 6-4. This table shows data developed from survey reporting of the producing companies for domestic refinery production from domestic and foreign sources, refined imports, refined from scrap, and producers' inventories at beginning and end of year. Total supply derived from these sources, exports of refined, and domestic consumption estimates based on deductions from total supply for exports and closing inventories are also presented. Sales of copper to GSA are included in the "apparent withdrawal domestic consumption" category.

TABLE 6-3 ANNUAL TRENDS IN COPPER PRODUCTION ACTIVITIES FOR THE UNITED STATES, 1962 THROUGH 1971 (THOUSANDS OF TONS)

Year	Mine Production	Smelter Production[1]	Primary Refinery Production (From Domestic + Foreign Ores)			Refinery Production From Scrap[2]		Total Refined Production[2]	Nonrefined Secondary Recovery[3]	Grand Total Copper Production[4]
			Electrolytic	Fire Refined	Lake	Primary Plants	Secondary Plants			
1962	1228	1282	1477	67	67	250	40	1901	632	2533
1963	1213	1258	1452	80	64	259	43	1898	672	2570
1964	1246	1301	1510	83	63	300	51	2007	742	2749
1965	1352	1403	1533	107	71	388	57	2156	808	2964
1966	1429	1430	1535	107	69	438	53	2202	843	3045
1967	954	841	1013	66	54	343	63	1539	754	2293
1968	1204	1235	1233	126	78	343	73	1853	802	2655
1969	1545	1547	1523	144	76	413	86	2242	877	3119
1970	1706	1606	1575	124	66	351	61	2277	735	3012
1971	1533	1471	1534(5)	---	58	342	57	1990	714(6)	2704

(1) Domestic ores only.

(2) Unalloyed Copper only.

(3) Copper content only of recoverable brass and bronze alloys and chemical products.

(4) Total U.S. copper production from ores, scrap, and brass and bronze alloys, regardless of country origin.

(5) Includes fire-refined.

(6) Estimated.

SOURCE: Bureau of Mines

TABLE 6-4 PRODUCTION, SUPPLY, AND PRODUCERS' STOCKS OF REFINED COPPER METAL IN THE U.S. (THOUSANDS SHORT TONS)

Year	Producers' Opening Refined Stocks	Refinery Production from Domestic Ores	Refinery Production from Foreign Ores, Blister	Imports of Refined Copper	Total Supply of Virgin Copper	Refined Copper from Scrap	Total Supply of Refined Copper	Exports of Refined Copper	Apparent Withdrawal for Domestic Consumption	Producers' Closing Refined Stocks
1962	64	1214	398	99	1775	433	2208	350	1787	71
1963	71	1219	377	119	1786	416	2202	337	1813	52
1964	52	1260	397	140	1849	422	2271	311	1923	37
1965	37	1336	376	137	1886	513	2399	325	2039	35
1966	35	1353	356	164	1908	535	2443	273	2127	43
1967	43	847	286	331	1507	483	1990	159	1804	27
1968	27	1161	276	400	1864	521	2385	241	2096	48
1969	48	1469	274	131	1922	575	2497	200	2258	39
1970	39	1521	244	132	1936	504	2440	221	2089	130
1971	130	1411	181	164	1886	400	2286	188	2023	75

SOURCE: Bureau of Mines

In terms of U.S. trade balance, this country is a net importer of refined and semi-refined copper, as shown by the "additions to domestic supply" column in Table 6-5. The net imports for the most recent ten years has normally ranged from 6 to 10 percent of total refined supply. During the period of shortages in 1967 and 1968, imports accounted for 20 percent of refined supply.

The domestic tariffs on primary copper products has generally been low. Currently, refined copper imported in the United States is assessed with a tariff of \$0.008 per pound. Ores, blister, anode, and scrap are essentially duty-free. However, there are quota limitations on exports. In 1969, exports of refined copper from domestic sources and scrap were limited to 50,000 and 60,000 short tons, respectively.

Foreign tariffs on primary copper products are also generally low. Many countries, such as Scandinavia, Austria, Switzerland, and those of the European Economic Community admitted unwrought copper duty-free. In Britain, tariff has ranged from zero to 10 percent ad valorem.

Capacity

In consideration of the nature of operations of copper extraction from ores, estimation of smelters capacity and production/capacity ratios is complex. Based on the available data in literature and on assumptions concerning concentrate analysis for each smelter, estimates have been derived for smelters capacity in terms of copper production.(1) These data are shown in Table 6-6 for 1970 and 1975, along with statistics on 1971 smelter production and related mining capacity data. During the recession year of 1971, smelters operated at 82 percent capacity which compares with 90 percent for the prosperous year of 1970.

Based on recent announcements in the literature, capacity additions at Magma and the new Tyrone, N.M., smelters will not offset the potential closures at Douglas, Arizona, and Tacoma, Washington. Assuming that these two smelters will shut down, overall industry capacity will decline from 1,855,000 tons per year to 1,785,000 tons per year. Meanwhile, mine expansions from 1,820,000 tons per year to 2,017,000 tons per year suggest that possible shortage in smelting capacity will occur. This shortage may also

TABLE 6-5 TRADE BALANCE FOR THE UNITED STATES (THOUSANDS OF SHORT TONS)

Year	Exports(2)	Imports(1)	Additions to Domestic Supply
1962	351	479	128
1963	326	539	213
1964	365	584	219
1965	372	518	146
1966	293	574	281
1967	237	637	400
1968	361	717	356
1969	212	410	198
1970	307	391	84
1971	242	355	113

(1) Concentrates; Regulus; Blister; Refined in Cathodes, Ingots, Bars

(2) Concentrates; Refined in Ingots, Bars, Cathodes; Old Scrap

SOURCE: Bureau of the Census

TABLE 6-6 PRODUCTION/CAPACITY DATA FOR COPPER SMELTERS
(1000 Tons of Copper)

Company	1971 Estimated Smelter Production	1970 Estimated Smelter Capacity(1)	Announced Capacity Additions	Possible Closures	1975 On-Stream Smelter Capacity
ASARCO	300	390	---	110	280
Anaconda	138	210	---	---	210
Inspiration	96	140	---	---	140
Kennecott	470	540	---	---	540
Magma	102	100	50	---	150
Phelps Dodge	345	370	100	110	360
White Pine	58	90	---	---	90
Cities Service	18	15	---	---	15
Total Smelters	1527	1855	150	210	1785
Estimated U.S. Mining Capacity(2)		1820	197	---	2017

(1) Arthur D. Little estimates.

(2) American Metal Market.

pose a problem for the U.S. economy in the expectation of an expansion through 1975. Should this expectation materialize, foreign imports of refined material may be expected to increase, along with higher prices.

In light of recent discussions among industry, government agencies, citizens, and court magistrates, it appears that implementation of regulations to meet air quality standards may intensify this shortfall between smelter capacity and mine capacity or between smelter production and demand. Under some proposed plans, smelters may curtail production at some existing sites in conjunction with the application of acid plant technology on the richer gas streams from smelting operations to meet primary ambient air quality standards.

Consumption

Refined copper and copper-based scrap are materials used by wire and brass mills to produce copper wire, cable, plates, sheets, strips, bars, and rods. Wire mills produce goods for electrical and communications industries; brass mills, for the machinery, construction, and consumer-oriented industries. In addition, a very small portion of copper is consumed in chemicals production. Statistics on consumption by fabricators are shown in Table 6-7. End-uses of products sold by fabricators are shown in Table 6-8 for: building construction, transportation, consumer and general products, industrial machinery, and electrical-electronic products.

The largest volume of consumption has been in electrical and electronics category. Demand for products in this category grew at a rate of 9.5 percent from 1961 until the labor strike in 1967. The decline in consumption for 1967 and 1968 is related to permanent substitution of aluminum, particularly for power transmission lines. Electrical products manufactured include motors, generators, test equipment, electrical wire for universal application, industrial controls, printed circuits, power distribution equipment, and electronic navigation and communication equipment.

An important area that has enjoyed a high, steady growth at a rate of 8.5 percent for the ten years, has been the consumer and general products category. In spite of the shortages due to strikes and of high prices in the

TABLE 6-7 CONSUMPTION OF REFINED COPPER BY FABRICATORS IN THE UNITED STATES (THOUSANDS OF SHORT TONS)

Year	Apparent Withdrawal for Domestic Consumption(1)	Consumption by Fabricators(1)	Wire Mills	Brass Mills	Foundries & Chemical Plants	Net Consumption by Fabricators(2)
1962	1787	1609	935	634	40	1519
1963	1813	1753	1027	690	36	1569
1964	1923	1864	1111	712	41	1727
1965	2039	2035	1228	767	40	1823
1966	2127	2379	1376	940	63	2134
1967	1804	1982	1274	659	49	1675
1968	2096	1878	1186	654	38	1671
1969	2258	2145	1295	800	50	1926
1970	2089	2027	1324	658	45	1807
1971	2023	2001	1325	647	29	1762

(1)Discrepancies between apparent withdrawal and fabricators' consumption can partially be explained by GSA purchases and sales.

(2)Copper content of fabricators shipments to consumers of finished or semi-fabricated materials produced from purchased refinery shapes as reported by United States Copper Association.

SOURCES: Bureau of Mines, U. S. Copper Association

TABLE 6-8 END USES FOR DOMESTIC COPPER CONSUMPTION(1) FOR MOST RECENTLY AVAILABLE 10-YEAR PERIOD (THOUSANDS OF SHORT TONS)

Year	Building Construction	Transportation	Consumer & General Products	Industrial Machinery & Equipment	Electrical & Electronic Products	Total(2)
1961	482	264	308	399	540	2007
1962	559	266	320	434	562	2203
1963	583	304	344	483	606	2319
1964	677	317	358	502	679	2640
1965	702	359	423	513	737	2800
1966	713	387	461	548	846	3152
1967	577	395	650	433	704	2694
1968	559	305	675	426	708	2696
1969	630	344	659	469	797	2958
1970	574	367	695	439	758	2620

(1) Consumption figures include refined copper and recovered copper-based alloys.

(2) All values presented in actual copper weights.

SOURCES: Copper Development Association, Charles Rivers Associates late sixties, demand for products in this category seemed unabated. Products in this category include jewelry, cookware and cooling utensils, clocks, watches, coinage, decorative applications, and various and sundry types of gages and instruments.

Overall, the annual growth rate (compounded) for consumption of copper in both refined and unrefined forms has been 3.2 percent, based on simple linear regression of data for the years of 1961 through 1970. This growth rate over a cyclical period takes into account two business recessions, one armed conflict, and one major labor strike, all of which caused upsets in supply-demand balances and price distortions.

Based on the performance of the U.S. economy in general for the last ten years, an assumption of a 3 percent growth rate seems reasonable in light of the expected annual 4 percent rate of increase in real growth through 1980 by the Department of Commerce. This has been the experience of the 1960's.

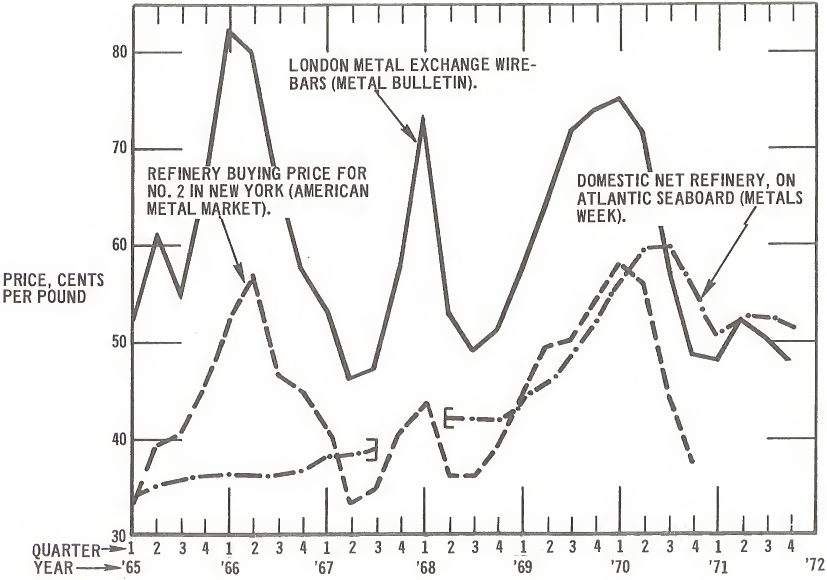
Prices

Copper is an international commodity and its price is sensitive to competitive forces between ever increasing demands by consumers, particularly in affluent economies, and rather rigid, oftentimes unreliable, sources of materials. Hence, price distortions are expected at times during political upheavals in underdeveloped countries and labor strikes, which constrict supplies, or wars and armed conflicts, which require copper for ordnance.

Key prices that are often watched by merchants, speculators, economists, and analysts are the London Metal Exchange (LME) price electrolytic wire bars and the U.S. producers' price as set by the major domestic producers. Copper scrap prices are also closely watched, as they reflect the supply of secondary sources of copper. The LME, the producers', and No. 2 scrap prices are shown in Figure 6-1

An explanation of these different price indicators follows. The LME is a cash (or spot) price determinant based on merchants' inventories in London warehouses. In volume, these stocks constitute no more than 3 or 4 weeks of available supply for a consumer of the magnitude of the U.S. economy. By its nature then, the LME represents a marginal price transaction thus, a short-term indicator. Other price indicators, such as the No. 2

Figure 6-1 Quarterly price movements for electroytic wirebars and No. 2 copper scrap.



scrap price (one of several price quotations published by American Metal Market for various grades of copper, brass, and bronze scrap) and the New York Commodity Exchange price (COMEX, quoted daily in the Wall Street Journal) for the merchants' auction market in the U.S. move harmoniously with the LME indicator.

The domestic producers' price is a firm price for contracts with large volume consumers of refined metal that is set by the major producers, such as Phelps Dodge or Kennecott. This price takes into accountthe long-term price level, reflecting producers' supply capabilities, costs, and profitability, that will assure copper consumers adequate supplies at a fair cost (to the consumer) without irreversible substitution to another metal during any pro-longed shortage.(2) The major producers will watch inventory statistics and price indicators, like the LME or the COMEX, for any noticeable change in available inventories in the hands of merchants, scrap dealers, etc. and will accordingly adjust their price. This is illustrated by the long-term rise indicated by the 3 movements in Figure 6-2 for the period of September 3, 1968 through October 1, 1970, and the resultant re-adjustment.

Under the assumption that demand pressures were strong world-wide, a minimum price difference of approximately 2 cents between the COMEX and LME tends to support the supposition of 2 cents per pound (2) for shipping copper between transocean points. (The fall of price during 1970 is a disequilibrium phenomenon as merchants and producers were trying to deplete heavy inventories.) Late in 1972, after market equilibirum was restored, the U.S. producers' price stabilized at approximately 3 cents above the LME, a difference which takes into account tariff and shipping.

Factors of production

In the cost structure of copper production, a division between mining and extraction seems the most simplistic way for understanding mechanisms of transferring increased costs of pollution control. Mining is that portion of the operating that comprises of breaking-up ores and produces concentrates for smelting. Extraction, for purposes of discussion, includes the smelting and refining of copper. Extrusion, rolling, and general fabrication is another operation beyond the scope of this work.

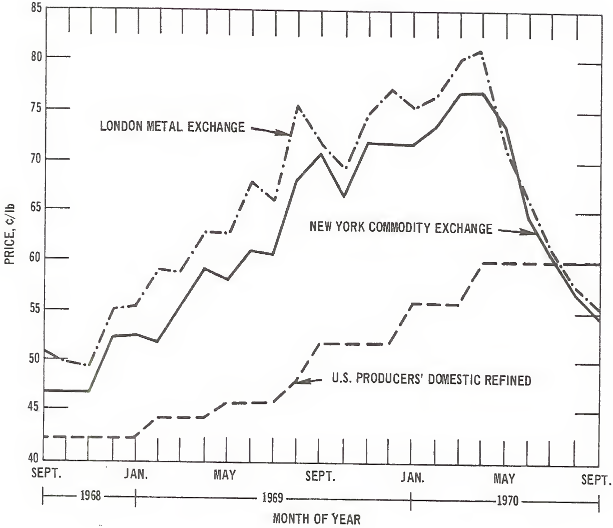


Figure 6-2 Price movements for refined wirebars on a monthly basis for two major-action markets and U.S. producers, September 1968 September 1970.

In the copper industry, mining costs are generally in inverse proportion to the copper content of an ore body. The smaller the content of copper, higher are the quantities of earth material that have to be crushed, hauled, and separated to produce a unit of copper. U.S. mineable ores average about 0.75 percent copper. In Africa, ores may be as high as 2 to 3 percent in copper. Other factors are also important besides the copper content. These include the by-product values, such as the recoverable quantities of gold, platinum, silver, tellurium, molybdenum, and many others. Negative by-product factors are sometimes present, including arsenic, and mercury. These factors are negative in the sense that ores containing these materials are limited to potential smelter markets because of the difficulty in handling arsenic, etc. Transportation is important. Beneficiation mills, which are located at mine sites, are important in production of concentrates that will assist in transporting copper values to smelter markets at minimum costs.

Mining costs are not uniform in the United States. For the major companies' mines, mining costs range from 23 to 40 cents per pound metal, according to Arthur D. Little.

Turning aside to the smelting and refinery of copper, some semblance of an income statement must be developed to assess the impact of air pollution control. Statistics presented in Table 6-9 for an eight-year period for smelters and refiners provide background information on the cost of materials, wages, capital expenditures, overhead and profit. This information, coupled with data from corporate annual reports, can be used to develop a model income statement for a smelter. The income statement simulated for a model smelter-refiner complex is shown as follows:

Model Income Statement ($1000's)

	Total Amount	Unit Cost, ¢ per lb
Sales[(a)]	104,000	52.0
Cost of Concentrates	84,000	42.0
Payroll, fuels, parts, repairs	10,400	5.2
Selling, general, administ.	3,000	1.5
Plant Depreciation	3,000	1.5
Operating Profit	3,600	1.8
Taxes	1,800	0.9
Net Earnings after Taxes	1,800	0.9
Cash Flow	4,800	2.4

[(a)] Based on 100,000 tons of copper per year

TABLE 6-9 SELECTED STATISTICS AND OPERATING RATIOS, 1960-1967 (S.I.C. 3331 PRIMARY SMELTING AND REFINING OF COPPER)

Year	Value of Shipments ($ Million)	Total Number of Employees (1000)	Total Payroll ($ Million)	Total Payroll Per Dollar of Shipments ($)	Number of Production Workers (1000)	Production Worker Wages ($ Million)	Wages Per Dollar of Shipments ($)	Cost of Materials ($ Million)	Capital Expenditures ($ Million)	Cost of Materials Per Dollar of Shipments ($)	Capital Expenditures Per Dollar of Shipments ($)
1960	1134	16.1	93.8	0.083	13.8	74.0	0.065	924	10.3	0.81	0.009
1961	1169	15.4	92.8	0.079	12.9	72.4	0.062	923	15.1	0.79	0.013
1962	1207	15.3	95.9	0.079	12.8	75.7	0.063	961	10.4	0.80	0.009
1963	1245	14.9	96.1	0.077	12.7	77.9	0.063	970	13.1	0.78	0.011
1964	1363	14.9	96.4	0.071	12.7	77.7	0.057	1077	9.2	0.79	0.007
1965	1584	15.2	105.1	0.066	13.1	85.1	0.054	1307	16.7	0.81	0.011
1966	1701	15.8	113.7	0.067	13.4	91.9	0.054	1349	39.9	0.79	0.023
1967	1184	11.6	80.6	0.068	9.2	61.0	0.052	935	51.7	0.79	0.044

SOURCE: Census of Manufacturers (U.S. Department of Commerce)

This statement, developed for a custom smelter-refiner, would be equivalent to operations in a vertical integrated company. The most important point reflected in the above statement is that the value added at the smelter-refiner complex (about 10¢ per lb.) is constant regardless of fluctuating copper prices. Furthermore, this increment seems fairly uniform from location to location in the United States.

New capacity

Consumption is expected to grow through 1980 at 3.2 percent compounded annually, based on previous performance and expected 4 percent growth in Gross National Product (GNP). Assuming that the contribution from primary and secondary sources will not change from the present patterns, smelter production will have to increase from the 1,500,000 ton rate in 1971 to approximately 2,000,000 tons in 1980.

Likely on-stream capacity available in 1975 will be approximately 1,800,000 tons per annum. Assuming an operating ratio of 0.80 to 0.90, total capacity to supply 1980 needs is estimated at 2,200,000 to 2,5000,000 tons per annum. The conclusion is that an addition 400,000 to 700,000 tons of capacity will have to be supplied in the form of smelter expansions, new domestic, or foreign smelters.

Phelphs Dodge recently announced plans to construct a new grass-roots smelter at Tyrone, New Mexico and it is very probable that an additional grass-roots smelter will be built to handle the outputs of Southwest U.S. mines. In recent years, this is the area where new mines have been developed. Many of these mines which sell concentrates to a custom smelter are owned by firms too small in mining activities as a result of limited capital resources or pursuits in oil production or manufacturing. Only recently Bagdad and Cyprus Mines (whose Pima Mining Company operates in Arizona) announced plans of merger.(3) Similar corporate combines might eventually evolve in a consortium with sufficient capital resources to build a new town-site smelter. Certainly, Bagdad(4) and Cerro Corporation(5) have expressed intentions of building a smelter in the past.

With regard to existing smelters, expansion in added capacity may be expected at San Manuel, Arizona and Anaconda, Montana. Magma has built an electrolytic refinery capable of producing 200,000 tons per year. Capacity for 1975 at San Manuel is scheduled at 150,000 tons per year. Anaconda has announced plans to test a hydrometallurgical unit in Montana.(6) Their intentions indicate expansion of facilities in that state.

In the late 1960's, new mines were opened in Canada and the South Pacific (viz., Bougainville and West Irian). Based on data available, 95,000 tons of Bougainville's projected 180,000 tons annual output(8) is contracted for Japan through 1975. This one sample indicates opportunities for capital investment (provided by U.S., Japanese, or other foreign firms) in new smelting facilities overseas for purposes of shipping metal to the U.S. American companies from time to time have been investigating overseas mining prospects in Australia and Irian.

As stated earlier, mining capacity is expected to reach 2,000,000 tons annually by 1975. Smelter capacity can be expected to expand to accommodate this supply of copper concentrates. This would mean that one new grass-roots smelter (excluding the Tyrone, New Mexico facility) would be required. Beyond this, the incremental demand in copper would have to be suppled by added capacity (100,000 tons per annum) to existing smelters and by foreign imports (200,000 tons per annum).

6.1.2 Cost Analysis of Alternative Control Strategies

6.1.2.1 Control cost analysis

Introduction

The financial expenditures necessary to control sulfur dioxide emissions are developed in this section for four basic types of pyrometallurgical smelters. Cost estimates are developed for capital expenditures based on the construction of new town-site smelters. Additionally, various control alternatives achieving sulfur dioxide control efficiencies from 70 to 99^+ percent (assuming total capture by exhaust hoods, no fugitive emissions, and no downtime in control equipment) are costed for these four basic smelter types.

Model plant characteristic

The model smelter is based on processing 1000 tons per day of new metal bearing material of the following analysis:

1. Copper (Cu) - 27%
2. Iron (Fe) - 28%
3. Sulfur (S) - 32%
4. Silica - 8%
5. Alumina - 2%
6. Lead, Zinc, Other - 3%
7. Precious Metal Values - minute quantities

Based on discussions with consultant engineers, it appears that a smelter of this capacity is representative of the smallest viable operation that could be built today.(9) Thus, in this respect, this development is biased somewhat toward identifying high costs with various levels of sulfur dioxide control, since larger installations would be able to take advantage of the inherent "economics-of-scale" associated with building large sulfur dioxide control systems. The concentrate analysis, however, may be considered "typical" of concentrates available in the southwestern United States. Although variations in concentrate analysis such as the ratio of copper to sulfur for example, significantly influence the control costs associated with various levels of sulfur dioxide control, these variations are not taken into account. Rather than examine the extremes, or biasing the results toward one extreme or the other as in the case of smelter capacity, the development is based on an "average" or "typical" concentrate which should lead to "average" or "typical" control costs. Consquently, the control costs developed are considered to represent, for the most part, "average" or "typical" order-of-magnitude costs.

The model smelter produces approximately 86,000 tons of copper per year (260 tons per day) and generates 620 tons per day of sulfur dioxide. This assumes a 2 percent loss of copper and 3 percent loss of sulfur in slag products.

Plant economics

Capital

Order-of-magnitude estimates of capital investment have been developed based on the available literature, and contact with construction firms, consultants, industry representatives, and the American Mining Congress. Tabulated costs of various elements in the construction of the basic four types of smelters are presented in Table 6-10, in 1973 dollars.

The data in Table 6-10 are assembled to show the total capital for a grass roots smelter, added capital for pollution control (all off-gases), and town-site investment requirements. Cost data for new, complete town-site smelters for the four basic technologies are as follows:

Technology	Capital ($ millions)
1. Flash Smelting	99-108
2. Hot Calcine Reverberatory Smelting	100-112
3. Green Charge Reverberatory Smelting	98-110
4. Electric Furnace Smelting	90-98

These data show that flash smelting and electric smelting have a slight advantage in lower capital requirements than the conventional reverberatory smelting methods. However, there are situations where the flash or electric smelting may not be as viable as the above capital costs suggest. For example, in Arizona electric power is presently not available to any potential newcomers desiring to plan an electric smelter and with flash smelting, high lead and zinc levels in the concentrates may require special design (higher cost) in the waste heat boiler section of the flash furnace.

TABLE 6-10 ELEMENTS OF CAPITAL COSTS FOR SMELTER TECHNOLOGIES ($1000's)

Total Direct Costs	Flash Smelter	Electric Furnace Smelter	Green Charge Reverb Smelter	Hot Charge Reverb Smelter	Comments
A Concentrate & Flux Handling	1600	1600	1600	1600	
B Dryer & Air Preheater	1280	1280	----	----	
C Furnace & Waste Heat Boiler	5900	5300-6700	4600	4700	Electric Furnace Includes Substation, No Waste Heat Boiler
D Flue Gas & Dust Handling	1900-3400	1600-2700	3000-5300	2100-3800	Hot Gas Fans, Electrostatic Precipitaters, High Velocity Flues, Dampers, Gates, Radiant Cooling
E Converter Aisle	5000	5000	5000	5000	Includes 3-13x30 Pierce Smith Converters, Converter Crane, Platforms, Blowers, Conventional Uptakes
F Anode Casting Facility	1200	1200	1200	1200	2 Holding Furnaces, Casting Wheel
G Fluo-Reactor	----	----	----	3400	
H Power Plant	2700	----	4000	2900	
I Slag Plant	2700	----	----	----	
J Miscellaneous Facilities	1300	1300	1300	1300	
K Site Clearance	1100	1100	1100	1100	
L Electrical Wiring	2100-3400	2100-3400	2100-3400	2100-3400	
M Buildings & Plant Facilities	1100-2100	1100-2100	1100-2100	1100-2100	
Total Direct Costs	30,000	24,100	37,300	28,600	

TABLE 6-10 (Con't) ELEMENTS OF CAPITAL COSTS FOR SMELTER TECHNOLOGIES

Total Direct Costs	Flash Smelter	Electric Furnace Smelter	Green Charge Reverb Smelter	Hot Charge Reverb Smelter	Comments
Construction, Supervision & Equipment	4500	3600	4100	4300	15% of Direct Costs
Engineering & Home Office	4200	3400	3800	4000	14% of Direct Costs
Indirect Costs	10,500	8500	9500	9900	Start-up Contingency, Administrative, Expenses, Fees (35% of Directs)
Total Capital	49,100	39,600	44,700	46,800	
Added Capital for Pollution Control	12,800-16,000	12,800-16,000	16,000-22,500	16,000-22,500	Required to Achieve 90-95% Control(1) (excluding acid neutralization)
Added Capital for Townsite Smelter	37,500-42,800	37,500-42,800	37,500-42,500	37,500-42,800	Land, Townsite, Utilities (Town), Waste Treatment Plant, Highways, Railroads, Office Buildings, Warehouse, Maintenance, Power Plant (Town & Smelter), Wells, Slag Disposal Area

SOURCES:

(a) Flash furnace technology - References 1, 2, and 3.
(b) Electric furnace technology - References 4 and 3.
(c) Conventional reverberatory smelting technology - References 1 and 6.
(d) General cost information on auxillary equipment - References 3, 6, and 5.

Notes:

(1) Assuming total capture by exhaust hoods, no fugitive emissions and no downtime of control equipment.

Operating Costs

Order-of-magnitude estimates are presented here for the direct operating costs of flash smelting vs conventional green charge reverberatory smelting:

Item	Flash Smelter ($1000's)	Green Charge Smelter ($1000's)	Unit Cost
Supervision	132	168	$12,000/yr
Operating Labor	1001	889	$3.75/hr
Fuel	235	915	40¢/MCF
Power	366	--	1¢/kwh
Flux	456	1630	$15/ton
Maintenance Labor	443	375	$3.75/hr
Supplies	455	465	---
Copper Losses (Slag)	688	1380	50¢/lb
Steam Credit	(105)	--	1¢/kwh
Total (Actual)	3671	5822	
(Unit Basis)	2.1¢/lb	3.4¢/lb	

SOURCE: Lummus International

These data suggest a cost advantage, of 1.3 cents credited to flash smelting, although discussions with the Magma Copper Company indicate that cost advantages narrow to 0.4-0.5 cents. However, this does not take into account pollution control, plant overhead, plant amoritization, nor refining and shipping. Slag treatment costs (direct operating expenses) are included for flash smelting.

Control alternatives

The problem of controlling emissions of sulfur oxides from copper smelters has many facets in an economic sense. The difficulty of pollutant capture is one of those facets. Pollutant removal from the gas stream and its ultimate disposal constitute another facet to the overall problem of controlling smelter gas. To provide an overview of these facets, the economics associated with several control alternatives for each of the four basic types of pyrometallurgical smelters were developed. Sulfuric acid plants, sulfur plants and dimethylaniline (DMA) scrubbing units comprise the basic process modules used to construct the various control alternatives.

Due to the potential oversupply problems inherent in sulfuric acid manufacture at the western copper smelters, neutralization requirements were analyzed in those control alternatives incorporating acid plants.

The assumption of free, unlimited limestone is made in the analysis and capital and operating cost requirements have been developed from industry data.(10)

Sulfur plants were included in several of the control alternatives as an alternative to the production of sulfuric acid. The economics are based on sulfur plant technology similar to that commercialized by Allied Chemical at the Falconbridge Nickel smelter in Canada.

In order to limit the number of models developed, only DMA scrubbing was considered in this analysis. It is expected that the costs associated with DMA scrubbing are similar to those associated with other scrubbing systems such as sodium sulfite/bisulfite and ammonia. This scrubbing system produces a concentrated sulfur dioxide stream (∿ 100%) which can be used as feed to a sulfuric acid plant or sulfur plant.

Control cost of alternatives

The first step toward determining cost requirements of various control alternatives is to examine the basic process modules mentioned above, which are used to construct the various control alternatives. Capital estimates for turn-key projects derived for typical flowrates of either total gas or sulfur are presented in Table 6-11 with their respective scale exponents for extrapolation. The data have been scaled to 1973 dollars by using an annual inflation rate of 6.7 percent in construction costs. The information source for basis of the estimate is cited. Site clearance and hook-up of available off-site facilities are included in the estimates.

Operating costs are also presented in Table 6-11. The literature basis for utility requirements are referenced. Prices of utilities and labor have been taken as assumed in the Fluor study(11) which developed the earlier mentioned utility requirements. Prices of commodities are based on current quotations in the Oil, Paint, and Drug Reporter (October 1972).

Various combinations of emissions control processes were assembled for the four basic smelter type configurations and are presented in Figures 6-3 through 6-6. Based on physical process parameters developed from material balance data, cost estimates were derived for these control

TABLE 6-11 CAPITAL COSTS AND OPERATING REQUIREMENTS FOR CONTROL PROCESSES

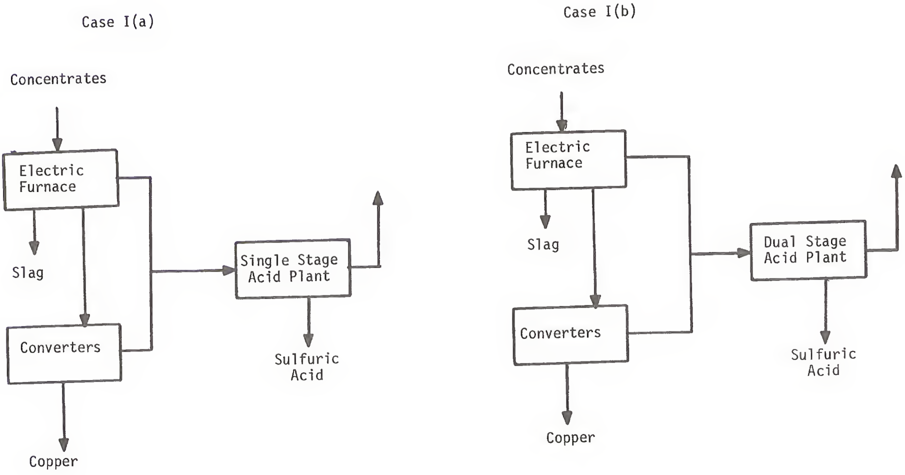
	Single Stage Acid Plant	Dual Stage Acid Plant	Elemental Sulfur Plant	Elemental Sulfur Plant	Dimethyaniline Absorption	Wet Cleaning Plant[2]	Unit Cost Factors
Plant Size	100,000 SCFM	100,000 SCFM	15,000 lb sulfur/hr (90% SO_2 in feed)	15,000 lb sulfur/hr (15% SO_2 in feed)	50,000 SCFM (5% SO_2 in feed)	50,000 SCFM	
Capital, $MM[1]	9.00	10.3	2.56	5.60	12.0[3]	2.54	
Capital Scale Factor	0.63	0.63	0.58	0.58	0.70	0.68	
Basis for Capital Estimate	Ref. 12	Ref. 14, 15	Ref. 8	Ref. 8	Ref. 7, 16	Ref. 12	
Basis for Utils.	Ref. 12	Ref. 15	Ref. 8	Ref. 8	Ref. 12, 8	Ref. 12	
Direct Operating Items							
Methane			13.4 MCF/Ton S	18.4 MCF/Ton S			40¢ per 1000 MCF
Electricity	4020 kw	4800 kw	40 kwh/Ton S	181 kwh/Ton S	1230 kw	300 kw	1¢ per kwh
Steam					14.7 Mlbs/hr		80¢ per Mlbs
DMA					12.6 lb/hr		26¢ per lb
Caustic Soda							$80 per ton
Soda Ash					0.20 ton/hr		$35 per ton
Sulfuric Acid					0.23 ton/hr		$15 per ton
Process Water	50,000 gal/hr	50,000 gal/hr		860 gal/ton S			50¢ per 1000 gal
Raw Water						25,000 gal/hr	25¢ per 1000 gal
Cooling Water	224 gal/ton S	224 gal/hr S	1700 gal/ton S	3600 gal/ton S	103,000 gal/hr		5¢ per 1000 gal
Catalysts			3.8 lb/ton S	3.8 lb/ton S			13¢ per lb
Operating Labor	72 manhours/day	72 manhours/day	54 manhours/day	54 manhours/day	24 manhours/day	24 manhours/day	$5 per manhour
Maintenance	6% of Capital	6% of Capital	5% of Capital	5% of Capital	6% of Capital	8% of Capital	

(1) Battery limits costs, including site clearance and hook-up of available off-site facilities.

(2) Wet cleaning plant capital must be added to capital for DMA and Sulfite/Bisulfite scrubbing units that receive smelter off-gas directly.

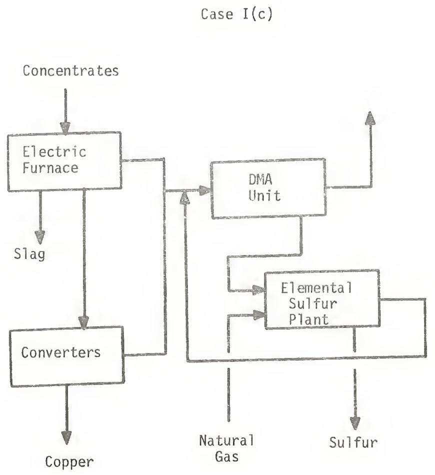
(3) Capital for a plant accepting 1.5% SO_2 feed (50,000 SCFM) would be $9.1 MM; operating requirements remain same as reported for the plant here with 5 feed.

Figure 6-3 Model copper smelting facilities-electric smelting options


Case I(a)

Case I(b)

Figure 6-3 (Con't) Model copper smelting facilities-electric smelting options



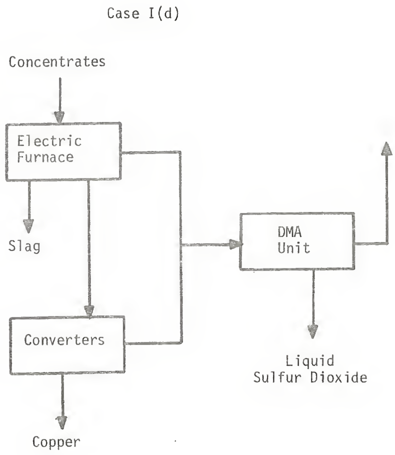
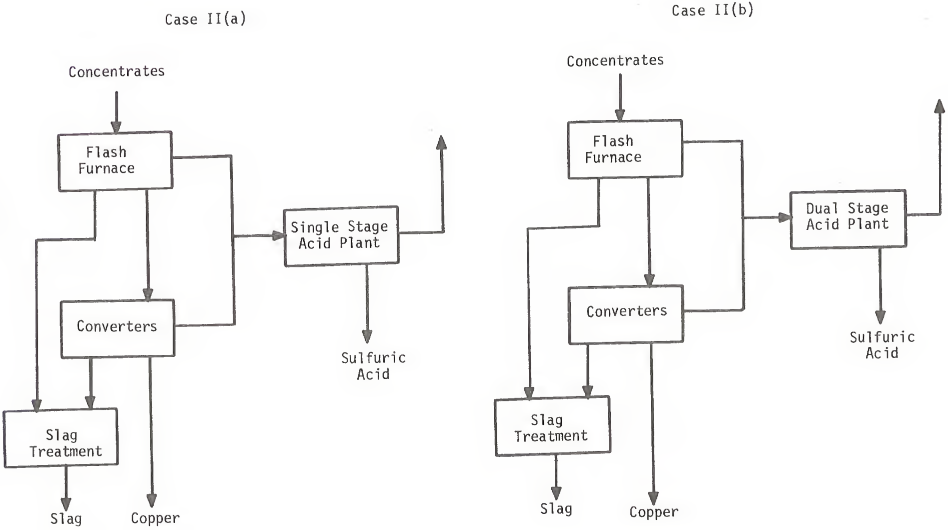


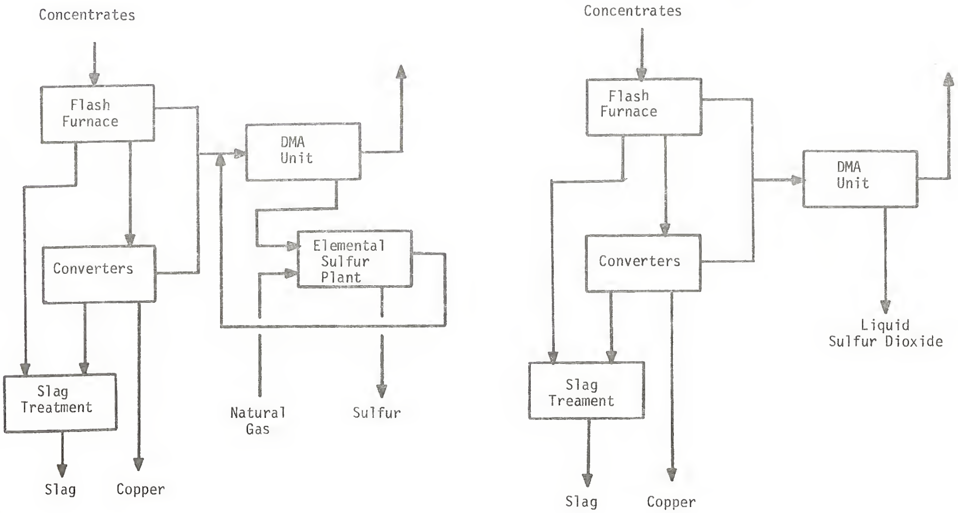
Figure 6-4 Model copper smelting facilities-flash smelting options.



Case II(a)

Case II(b)

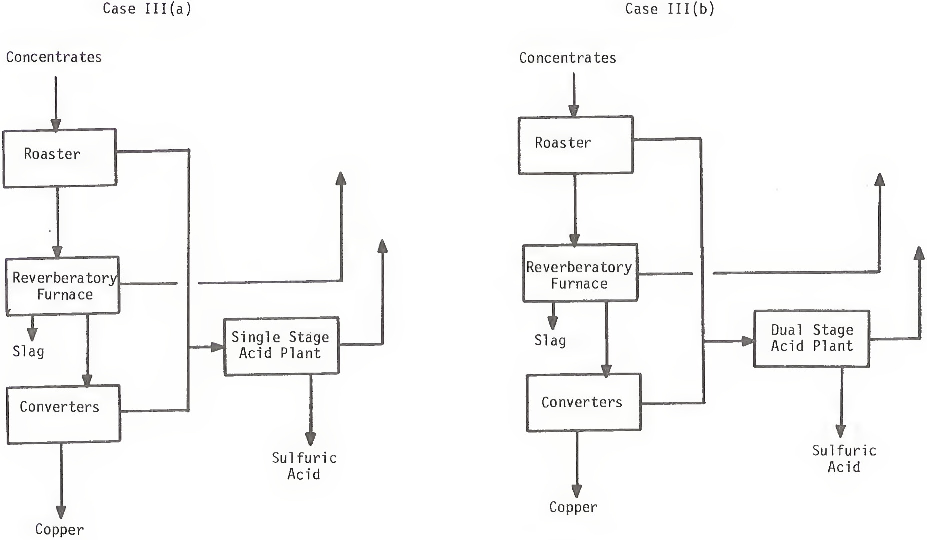
Figure 6-4 (Con't) Model copper smelting facilities-flash smelting options.



Case II(c)

Case II(d)

Figure 6-5 Model copper smelting facilities-roaster/reverberatory smelting options.



Case III(a)

Case III(b)

Figure 6-5 (Con't) Model copper smelting facilities-roaster/reverberatory smelting options.

Case III(c)

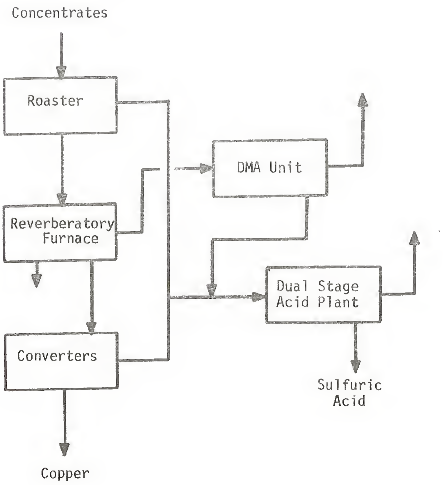
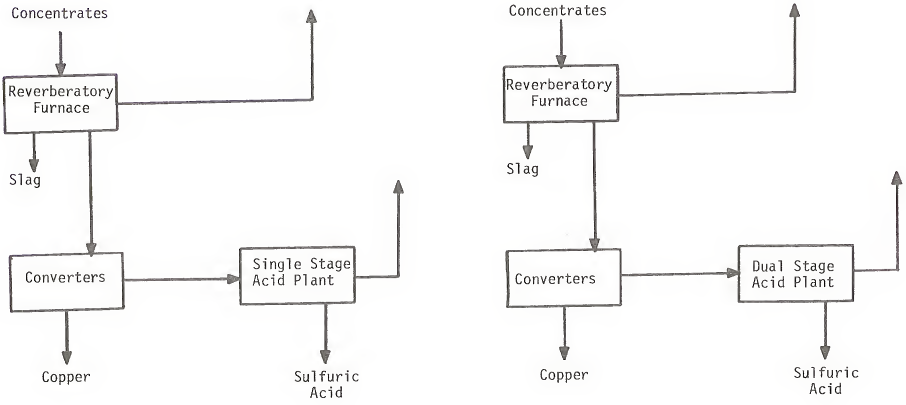
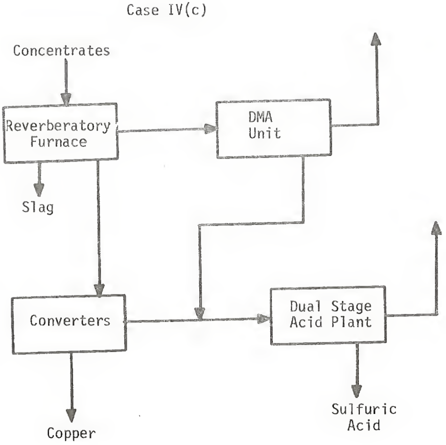


Figure 6-6 Model copper smelting facilities-reverberatory smelting options.


Case IV(a)

Case IV(b)

Figure 6-6 (Con't) Model copper smelting facilities-reverberatory smelting options.



combinations. Total capital and operating costs are presented in Table 6-12. In addition, the overall control of sulfur dioxide emissions, expressed as a percent, achieved with each control alternative is summarized. It is to be noted, however, that these percentages are theoretical in nature and are based on the assumptions of total capture by exhaust hoods with no fugitive emissions and no downtime of the control system. As a result, these overall control efficiencies are not representative of what could be achieved in actual practise, but are for discussion or comparative purposes only. For example, a recent EPA survey revealed fugitive emissions varying between 0% to 15% at existing domestic smelters.

Table 6-12 also presents control costs expressed in terms of cents per pound of copper produced and in terms of cents per pound of sulfur dioxide controlled. Finally, this table also presents various incremental control costs in terms of incremental cents per pound of copper produced and in terms of incremental cents per incremental pound of sulfur dioxide recovered. The basis for these incremental costs is explained in the footnotes to the table.

The costs presented represent incremental costs associated only with the treatment of pollutants. The cost of tight fitting, water cooled hoods have been included although other pieces of gas collection devices, such as headers, balloon flues, and ducts have not. Cost differences relevant to the various modes of furnace and converter operations have not been taken into account.

The derivation of the capital related charges is based on the following assumptions: (1) depreciation of 15 years (25 years for neutralization facility) for all equipment, (2) interest, insurance, and taxes at 10 percent of total invested capital, and (3) maintenance costs, estimated as percents (see Table 6-11 for actual percents) of total invested capital. Operating costs are the direct operating expenditures for payroll costs and utilities. The unit costs are based on production of 86,000 tons of copper per annum.

For all control alternatives, each smelter consists of one furnace to smelt 1000 tons per day of concentrate and 3 Pierce-Smith converters. Wet cleaning units consisting of scrubbers, mist precipitators, etc. are mandatory for treating all smelter source emissions. Metallurgical acid plants sold as turnkey units incorporate this feature. Therefore, wet cleaning requirements for acid plants are included in acid plant costs wherever such a plant is sized and costed. A brief discussion of each control alternative follows.

TABLE 6-12 CONTROL COSTS FOR MODEL COPPER SMELTING FACILITIES

Model No.	Control Equipment	Capital Cost ($MM)	Capital Charges ($MM/yr)	Operating Cost ($MM/yr)	Total Cost ($MM/yr)	Overall Control (%)	Control Costs Cents/lb Copper	Control Costs Cents/lb SO_2	Incremental Control Costs Δ Cents/lb Copper	Incremental Control Costs Δ Cents/Δ lb SO_2
	Electric Smelting									
Ia	Single Stage Acid Plant	10.2	2.31	0.57	2.88	97.5(1)	1.68(2)	0.72(2)	—	—
	Neutralization	5.4	0.96	0.97	1.93					
		15.6	3.27	1.54	4.81	97.5(1)	2.79	1.21	—	—
Ib	Dual Stage Acid Plant	11.4	2.59	0.62	3.21	99.5(1)	1.87(2)	0.79(2)	0.19(3)	4.34(3)
	Neutralization	5.5	1.00	0.99	1.99					
		16.9	3.59	1.61	5.20	99.5(1)	3.03	1.28	0.24(3)	5.13(3)
Ic	DMA Scrubbing	25.8	5.84	0.96	6.80					
	Sulfur Plant	3.5	0.76	0.73	1.49					
		29.3	6.60	1.69	8.29	99.5(1)	4.82(4)	2.04(4)	—	—
Id	DMA Scrubbing	23.4	5.30	0.86	6.16	99.5(1)	3.58(5)	1.52(5)	—	—
	Flash Smelting									
IIa	Single Stage Acid Plant	8.7	1.98	0.50	2.48	97.5(1)	1.45(2)	0.62(2)	—	—
	Neutralization	5.4	0.96	0.97	1.93					
		14.1	2.94	1.47	4.41	97.5(1)	2.56	1.10	—	—
IIb	Dual Stage Acid Plant	9.8	2.23	0.54	2.77	99.5(1)	1.61(2)	0.68(2)	0.16(3)	4.15(3)
	Neutralization	5.5	1.00	0.99	1.99					
		15.3	3.23	1.53	4.76	99.5(1)	2.77	1.17	0.21(3)	5.01(3)
IIc	OMA Scrubbing	20.2	4.57	0.73	5.30					
	Sulfur Plant	3.5	0.76	0.73	1.49					
		23.7	5.33	1.46	6.79	99.5(1)	3.95(4)	1.67(4)	—	—
Id	DMA Scrubbing	18.1	4.08	0.63	4.71	99.5(1)	2.74(5)	1.16(5)	—	—

TABLE 6-12 (Con't) CONTROL COSTS FOR MODEL COPPER SMELTING FACILITIES

Model No.	Control Equipment	Capital Cost ($MM)	Capital Charges ($MM/yr)	Operating Cost ($MM/yr)	Total Cost ($MM/yr)	Overall Control (%)	Control Costs Cents/lb Copper	Control Costs Cents/lb SO_2	Incremental Control Costs Δ Cents/lb Copper	Incremental Control Costs Δ Cents/Δ lb SO_2
	Roaster/Reverberatory Smelting									
IIIa	Single Stage Acid Plant Neutralization	8.7 4.8 13.5	1.98 0.87 2.85	0.44 0.78 1.22	2.42 1.65 4.07	78.5(1) 78.5(1)	1.41(2) 2.41	0.75(2) 1.27	— —	— —
IIIb	Dual Stage Acid Plant Neutralization	9.7 4.8 14.5	2.21 0.87 3.08	0.48 0.79 1.27	2.69 1.66 4.35	80.0(1) 80.0(1)	1.57(2) 2.56	0.82(2) 1.33	0.82(2) 0.15(3)	4.84(3) 5.01(3)
IIIc	DMA Scrubbing Dual Stage Acid Plant Neutralization	15.6 10.2 5.5 31.3	3.54 2.31 1.00 6.85	0.77 0.52 0.99 2.28	4.31 2.83 1.99 9.13	98.5(1) 98.5(1)	4.16(2) 5.30	1.77(2) 2.26	2.59(5) 2.74(5)	5.79(5) 6.22(5)
	Reverberatory Smelting									
IVa	Single Stage Acid Plant Neutralization	8.9 4.4 13.3	2.02 0.80 2.82	0.46 0.68 1.14	2.48 1.48 3.96	69.0(1) 69.0(1)	1.45(2) 2.30	0.89(2) 1.41	— —	— —
IVb	Dual Stage Acid Plant Neutralization	9.9 4.4 14.3	2.25 0.80 3.05	0.50 0.69 1.19	2.75 1.49 4.24	70.0(1) 70.0(1)	1.60(2) 2.46	0.96(2) 1.49	0.15(3) 0.16(3)	5.48(3) 5.69(3)
IVc	OMA Scrubbing Dual Stage Acid Plant Neutralization	17.0 10.1 5.4 32.5	3.85 2.23 0.96 7.04	0.84 0.50 0.98 2.38	4.69 2.79 1.94 9.42	98.5(1) 98.5(1)	4.36 5.48	1.85 2.33	2.76(6) 3.02(6)	3.99(6) 4.36(6)

Notes:

(1)Overall control efficiencies calculated assuming no fugitive emissions, no down-time of control equipment and tail gases from single stage acid plants containing 2000 ppm SO_2, from dual stage acid plants contailing 500 ppm SO_2 and from DMA scrubbing systems containing 500 ppm SO_2. EPA survey of existing copper smelters identified fugitive emissions varying between 0% and 15% of total SO_2 emissions vented to atmosphere.

(2)Acid sold at zero netback to smelter.

(3)Incremental control costs reflecting use of dual stage plant over single stage acid plant.

(4)Sulfur sold at zero netback to smelter.

(5)Liquid SO_2 sold at zero netback to smelter.

(6)Incremental control costs reflecting use of DMA scrubbing on reverberatory furnace off-gases over venting furnace off-gases directly to atmosphere.

Electric Smelting Options

Case Ia - Off-gases from the electric furnace at 6% sulfur dioxide are combined with off-gases from the copper converters at 7-10 1/2% sulfur dioxide, forming the feed to a single stage sulfuric acid plant and ranging in concentration from 6-8 1/2% sulfur dioxide. The off-gas flow rate from the electric furnace is 24,000 SCFM, while that from the converters ranges from 31,000-63,000 SCFM. Thus, the acid plant is sized to process peak off-gas flowrates of 87,000 SCFM, to produce 927 TPD of 100% sulfuric acid.

Case Ib - Essentially the same as Case Ia except this alternative incorporates a dual stage sulfuric acid plant rather than a single stage plant, resulting in the production of 944 TPD of 100% sulfuric acid.

Case Ic - Off-gases from the electric furnace are combined with off-gases from the copper converters, forming the feed to a DMA scrubbing unit. The DMA unit produces a concentrated sulfur dioxide gas (∿ 100%) which is processed by a sulfur plant. The off-gases from the sulfur plant containing 5 1/2% sulfur dioxide are recycled to the DMA unit for treatment with the combined electric furnace and converter off-gases. Due to the recycle of the sulfur plant tail gases, the DMA unit is sized to process peak off-gas flowrates of 101,000 SCFM. The sulfur plant is sized to process peak sulfur dioxide flowrates of 7700 SCFM, to produce 308 TPD of elemental sulfur.

Case Id - Off-gases from the electric furnace are combined with off-gases from the copper converters, forming the feed to a DMA unit. The DMA unit produces liquified sulfur dioxide. In this case, the DMA unit is sized to process peak off-gas flowrates of 87,000 SCFM.

Flash Smelting Options

Case IIa - Off-gases from the flash furnace at 10% sulfur dioxide are combined with off-gases from the copper converters at 7-10 1/2% sulfur dioxide, forming the feed to a single stage acid plant and ranging from 7-8% sulfur dioxide. The off-gas flowrate from the flash furnace is 28,000 SCFM, while that from the copper converters ranges from 16,000-32,500 SCFM. Thus, the acid plant is sized to process peak off-gas flowrates of 73,000 SCFM. Due to the high sulfur dioxide concentrations, air is blended with the feed to the acid plant to provide sufficient oxygen to convert sulfur dioxide to sulfur trioxide. The acid plant produces 929 TPD of 100% sulfuric acid.

Case IIb - Essentially the same as Case IIa except this alternative incorporates a dual stage acid plant rather than a single stage plant, resulting in the production of 945 TPD of 100% sulfuric acid.

Case IIc - Off-gases from the flash furnace are combined with off-gases from the copper converters, forming the feed to a DMA scrubbing unit. The DMA unit produces a concentrated sulfur dioxide gas (∿ 100%) which is processed by a sulfur plant. The off-gases from the sulfur plant containing 5 1/2% sulfur dioxide are recycled to the DMA unit for treatment with the combined flash furnace and converter off-gases. Due to the recycle of the sulfur plant tail-gases, the DMA unit is sized to process peak off-gas flowrates of 72,000 SCFM. The sulfur plant is sized to process peak sulfur dioxide flowrates of 6300 SCFM, to produce 309 TPD of elemental sulfur.

Case IId - Off-gases from the flash furnace are combined with off-gases from the copper converters, forming the feed to a DMA unit. The DMA unit produces liquified sulfur dioxide. In this case, the DMA unit is sized to process peak off-gas flowrates of 60,500 SCFM.

Roaster/Reverberatory Smelting Options

Case IIIa - Off-gases from a fluid-bed roaster at 10% sulfur dioxide are combined with off-gases from the copper converters at 7-10 1/2% sulfur dioxide, forming the feed to a single stage acid plant and ranging from 7-8% sulfur dioxide. Off-gases from the reverberatory smelting furnace at 1 1/4% are vented directly to the atmosphere. The off-gas flowrate from the roaster is 17,000 SCFM, that from the reverberatory furnace 76,000 SCFM while that from the copper converters ranges from 18,500-37,700 SCFM. Thus, the acid plant is sized to process peak off-gas flowrates of 63,000 SCFM. Due to the high sulfur dioxide concentrations air is blended with the feed to the acid plant to provide sufficient oxygen to convert sulfur dioxide to sulfur trioxide. The acid plant produces 748 TPD of 100% sulfuric acid.

Case IIIb - Essentially the same as Case IIIa except this alternative incorporates a dual stage acid plant rather than a single stage acid plant, resulting in the production of 760 TPD of 100% sulfuric acid.

Case IIIc - Off-gases from the fluid-bed roaster are combined with the off-gases from the copper converters, forming the feed to a dual stage acid plant. The off-gases from the reverberatory smelting furnace are fed to a DMA scrubbing unit. The DMA unit produces a concentrated sulfur dioxide gas (∿ 100%) which is also fed to the dual stage acid plant in addition to the roaster and converter off-gases. The DMA unit is sized to process 76,000 SCFM of off-gases and the acid plant is sized to process peak off-gas flowrates of 69,500 SCFM. The acid plant produces 946 TPD of 100% sulfuric acid.

Reverberatory Smelting Options

Case IVa - The off-gases from the reverberatory smelting furnace at 1 3/4% sulfur dioxide are vented directly to the atmosphere. The off-gases from the copper converters at 7-10 1/2% sulfur dioxide form the feed to a single stage sulfuric acid plant. The off-gas flowrate from the reverberatory furnace is 82,500 SCFM, while that from the copper converters ranges from 31,000-63,000 SCFM. Thus the acid plant is sized to process peak off-gas flowrates of 65,500 SCFM. Due to the high concentration of sulfur dioxide, air is blended with the feed to the acid plant to provide sufficient oxygen to convert sulfur dioxide to sulfur trioxide. The acid plant produces 651 TPD of 100% sulfuric acid.

Case IVb - Essentially the same as Case IVa except this alternative incorporates a dual stage acid plant rather than a single stage acid plant, resulting in the production of 660 TPD of 100% sulfuric acid.

Case IVc - The off-gases from the reverberatory smelting furnace form the feed to a DMA scrubbing unit. The DMA unit produces a concentrated sulfur dioxide gas (∿ 100%), which is combined with the off-gases from the copper converters and fed to a dual stage acid plant. The DMA unit is sized to process 82,500 SCFM, while the acid plant is sized to process peak off-gas flowrates of 75,500 SCFM. The acid plant produces 937 TPD of 100% sulfuric acid.

APPENDIX

E

APPENDIX

E

Comments on the draft environmental impact statement have been received from the following persons and organizations:

1. The Anaconda Company
   P. O. Box 689
   Butte, Montana 59701

2. Environmental Protection Agency
   Region VIII
   1860 Lincoln Street
   Denver, Colorado 80203

3. U. S. Department of Agriculture
   Forest Service
   Federal Building
   Missoula, Montana 59801

4. Honorable Dorothy Bradley
   Montana State House of Representatives
   P. O. Box 931
   Bozeman, Montana 59715

5. S. L. Groff, Director and State Geologist
   Montana Bureau of Mines and Geology
   Butte, Montana 59701

6. Dr. Arnold J. Silverman
   Professor of Geology
   University of Montana
   Missoula, Montana 59801

7. Dr. Clancy Gordon
   Professor of Botany
   University of Montana
   Missoula, Montana 59801

8. Mr. Phillip Tourangeau
   University of Montana
   Missoula, Montana 59801

9. Montana Wildlife Federation
   410 Woodworth Avenue
   Missoula, Montana 59801

10. Dr. David F. Aldrich
    106 First Avenue - Hillcrest
    Hamilton, Montana 59840

11. Mr. William P. Klein, Jr.
    P. O. Box 121
    Missoula, Montana 59801

13. Mr. Ralph L. Allen
310 Pattee Canyon Drive
Missoula, Montana 59801

14. Mr. Harold C. Lund
Associate State Director
U. S. Department of the Interior
Bureau of Land Management
State Office
316 North 26th Street
Billings, Montana 59101

All comments, corrections and criticisms have been studied and changes made to the text where applicable. All letters received will be kept in the files of the Department of Health and Environmental Sciences, Room 222, Cogswell Building, Helena, Montana, for a reasonable length of time. The public may inspect these documents at any time during office hours.

The background of persons contributing to The Anaconda Company variance impact statement are as follows:

Donald Holtz, Chief, Air Quality Bureau, B.S., Mechanical Engineering, Montana State University, 1960, registered professional engineer, Montana, nine years experience in air pollution control.

Carl Rinaldi, B.S., Botany, University of Massachusetts, 1968, M.S., Plant Pathology, Rutgers University, 1973, research on the effects of air pollutants on vegetation, seven months experience as an Air Pollution Control Specialist in Vegetation for the Air Quality Bureau.

David Maughan, B.S., Chemistry, Brigham Young University, 1968, M.A., Physical Chemistry, University of Utah, 1971, two years metabolic disease research, University of Utah School of Medicine, three years experience in air quality monitoring and related data processing meteorology and laboratory analysis with the Air Quality Bureau.

Daniel Vichorek, B.A., Journalism, University of Montana, 1969, experience as a general assignment and police reporter for the Billings (Montana) Gazette and the City News Bureau of Chicago, 16 months experience as a technical writer for the Environmental Sciences Division.

Don Willems, Chief, Water Quality Bureau, B.S., Sanitary Engineering, University of Illinois, 1951; M.S., Civil Engineering, University of Florida, 1959; registered professional engineer, Montana; Technical Service Engineer on water and wastewater equipment, Infilco, Inc., Tucson Arizona, 1951-56; experience in water pollution control with the State Department of Health and Environmental Sciences, 1956-58, 1959 to present.

James Brown, B.S., Civil Engineering, South Dakota School of Mines and Technology, 1970; M.S., Environmental Health Engineering, University of Texas at Austin, 1973; Public Health Engineer, South Dakota Department of Health, 1970-72; Public Health Engineer, State Department of Health and Environmental Sciences, September 1973 to present.

Fred O. Gray, B.S., Chemical Engineering, 1958, Montana State University; approximately 12 years experience as a test engineer in a research and development laboratory of The Boeing Company; two years experience as an air pollution engineer in a consulting firm, and 10 months as an Environmental Engineer in the Air Quality Bureau.